

***Sedentary Behavior* und die psychische Gesundheit im
Kindes- und Jugendalter – Differenzierte Zusammenhänge
und ein schulbasierter Ansatz zur Reduktion des sitzenden
Verhaltens**

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1 HINTERGRUND

1.1 *Sedentary Behavior* im Kindes- und Jugendalter

Das Ausmaß an *Sedentary Behavior* rückte in den letzten 20 Jahren zunehmend in den Fokus der Wissenschaft. Unter dem Begriff *Sedentary Behavior* („sitzendes Verhalten“) werden Aktivitäten im Wachzustand zusammengefasst, die in einer sitzenden oder liegenden Position ausgeführt werden und bei denen der Energieverbrauch im Vergleich zum Ruhezustand gar nicht beziehungsweise nur sehr geringfügig ansteigt, das bedeutet einen Energieverbrauch von 1,0 bis 1,5 metabolischen Äquivalenten (Pate, O'Neill, & Lobelo, 2008; Sedentary Behaviour Research Network, 2012). Der Lebensstil vieler Jugendlicher in modernen Gesellschaften ist von sitzenden/liegenden Verhaltensweisen geprägt, was unter anderem auf die vielfältigen Möglichkeiten der sitzenden/liegenden Freizeitgestaltung beispielsweise mittels Fernseher und Computer sowie motorisierte Transport- und Fortbewegungsmittel wie Bus, Bahn und Auto zurückzuführen ist. Nach aktueller Studienlage verbringen Kinder und Jugendliche in modernen Gesellschaften im Durchschnitt bis zu acht Stunden am Tag im Sitzen oder Liegen (Pate, Mitchell, Byun, & Dowda, 2011). Fernsehen und Computernutzung nehmen dabei den größten Teil der sitzenden/liegenden Freizeit von Kindern und Jugendlichen ein (Zabinski, Norman, Sallis, Calfas, & Patrick, 2007; Hardy, Dobbins, Booth, Denney-Wilson, & Okely, 2006). Während Jungen deutlich mehr Zeit als Mädchen mit Fernsehen und Computernutzung verbringen, gehen Mädchen häufiger sozialen Aktivitäten im Sitzen/Liegen nach als Jungen (Hardy et al., 2006).

Sedentary Behavior ist ein von der körperlichen Aktivität abzugrenzender Verhaltensbereich. Kinder und Jugendliche können gemäß Bewegungsempfehlungen als sehr aktiv eingestuft werden, doch zugleich überdurchschnittlich viel Zeit im Sitzen/Liegen verbringen (Wong & Leatherdale, 2009). In einer umfassenden Meta-Analyse von Pearson, Braithwaite, Biddle, van Sluijs und Atkin (2014) konnte zwar ein negativer Gesamtzusammenhang zwischen *Sedentary Behavior* und körperlicher Aktivität gefunden werden, dieser fiel jedoch verhältnismäßig gering aus ($r = -0,108$). Das bedeutet, dass körperliche Aktivität zu einem gewissen Umfang durchaus durch sitzende/liegende Freizeitbeschäftigungen ersetzt wird, beide Verhaltensbereiche jedoch auch unabhängig voneinander sind. Als wichtige Einschränkung dieser berichteten geringen Assoziation sind jedoch die häufig subjektiven Messmethoden sowie die damit teilweise einhergehende Fokussierung auf einzelne Intensitäten körperlicher Aktivität

beziehungsweise einzelne sitzende/liegende Verhaltensweisen zu nennen. Moderatoranalysen ergaben einen stärkeren Zusammenhang zwischen körperlicher Aktivität und *Sedentary Behavior* in Studien, die objektive Messverfahren einsetzten (Pearson, Braithwaite, Biddle, van Sluijs, & Atkin, 2014). Zudem berichteten Ekelund et al. (2012) zwar eine moderate inverse Korrelation zwischen *Sedentary Behavior* und moderater bis intensiver körperlicher Aktivität in einer gepoolten Stichprobe von Kindern und Jugendlichen, deren Bewegungsverhalten objektiv mit Akzelerometern gemessen wurde. Im Gegensatz dazu war die Assoziation mit der gesamten körperlichen Aktivität der Kinder und Jugendlichen, die auch leichte Intensitäten einschloss, aber deutlich stärker ausgeprägt.

Vor allem das Jugendalter ist hinsichtlich des bewegungsbezogenen Gesundheitsverhaltens eine besonders kritische Phase. Hier treffen zwei Phänomene aufeinander: Die moderate bis intensive körperliche Aktivität nimmt ab und das *Sedentary Behavior* zu (Raudsepp, Neissaar, & Kull, 2008). In einer auf objektiven Messungen per Akzelerometer basierenden Studie von Matthews und Kollegen (2008) verbrachten Mädchen im Alter von 6-11, 12-15 beziehungsweise 16-19 Jahren insgesamt 6,1, 7,7 beziehungsweise 8,1 Stunden pro Tag mit *Sedentary Behavior*. Jungen verbrachten etwas weniger Zeit im Sitzen/Liegen, zeigten jedoch den gleichen altersabhängigen Aufwärtstrend. Im Gegensatz dazu berichteten beispielsweise Nader, Bradley, Houts, McRitchie und O'Brien (2008) eine Abnahme der moderaten bis intensiven körperlichen Aktivität von 180 Minuten pro Tag im Alter von 9 Jahren auf 42 Minuten pro Tag mit 15 Jahren.

1.2 Psychische Gesundheit im Kindes- und Jugendalter

Nach Schätzung der Weltgesundheitsorganisation sind weltweit jährlich rund 20% der Jugendlichen von Beeinträchtigungen der psychischen Gesundheit betroffen (World Health Organization, 2012). Die häufigsten klinischen Diagnosen beinhalten Angststörungen, depressive Störungen und Verhaltensstörungen, wobei letztere bei Jungen häufiger auftreten als bei Mädchen (Merikangas, Nakamura, & Kessler, 2009). Im Gegensatz dazu ist die Prävalenz für Angst- und depressive Störungen bei Mädchen deutlich höher als bei Jungen. Psychische Störungen, vor allem unipolare Depressionen, zählen zu den führenden Ursachen der globalen Krankheitslast von Kindern und Jugendlichen zwischen 10 und 19 Jahren (World Health Organization, 2004). Zudem ist die Jugend eine sehr kritische Phase für die Entstehung psychischer Störungen, da sich erste Anzeichen häufig bereits in diesem Alter zeigen und bis ins Erwachsenenalter persistieren (Kessler et al., 2007).

Neben psychiatrischen Symptomen/Syndromen spielt für die psychische Gesundheit auch die Ausprägung des psychischen Wohlbefindens und der Lebenszufriedenheit eine wichtige Rolle. In der Verfassung der Weltgesundheitsorganisation wird Gesundheit daher als Zustand des physischen, psychischen und sozialen Wohlbefindens definiert und nicht nur als die Abwesenheit von Krankheit oder Beeinträchtigung (World Health Organization, 2002). Insbesondere die Pubertät ist mit vielfältigen, teils gravierenden Veränderungen assoziiert, die zu einer Instabilität des Selbst und einer höheren Vulnerabilität für Beeinträchtigungen der psychischen Gesundheit führen können (Patton & Viner, 2007). Während der Kindheit und Jugend ist eine ganze Reihe von Entwicklungsaufgaben zu lösen: zum Beispiel der Erwerb sozialer Kompetenzen, Autonomie oder Identitätsbildung (Oerter & Montada, 2008). Eine schlechte psychische Gesundheit steht auch mit Problemen bei der Bewältigung solcher zentralen Entwicklungsaufgaben in Verbindung und kann damit weitreichende Folgen haben (Patel, Flisher, Hetrick, & McGorry, 2007).

1.3 *Sedentary Behavior* als gesundheitlicher Risikofaktor

Die gesundheitsförderlichen Effekte von moderater bis intensiver körperlicher Aktivität im Kindes- und Jugendalter sind sehr gut belegt. Hierzu zählen unter anderem sowohl ein günstigeres kardiometabolisches sowie kardiovaskuläres Risikoprofil (Ekelund et al., 2012; Janssen & LeBlanc, 2010; World Health Organization, 2010) als auch eine bessere psychische Gesundheit (Ahn & Fedewa, 2011; Biddle & Asare, 2011). Für die Bewertung eines hohen Ausmaßes an *Sedentary Behavior* als gesundheitlicher Risikofaktor ist die Befundlage noch nicht derart breit, dennoch konnten negative Effekte vor allem auf die physische Gesundheit im Kindes- und Jugendalter belegt werden: Kinder und Jugendliche, die viel Zeit mit sitzenden/liegenden, vor allem bildschirmgebundenen Aktivitäten verbrachten, zeigten unter anderem ein höheres Risiko für Übergewicht und eine ungünstige Körperzusammensetzung, Bluthochdruck, erhöhte Cholesterinwerte sowie eine schlechtere kardiorespiratorische Fitness (Tremblay et al., 2011; de Rezende, Rodrigues, Rey-Lopez, Matsudo, & Luiz, 2014). Des Weiteren wurden in einigen Studien additive Effekte berichtet, das heißt, die Kombination aus einem hohen Ausmaß an *Sedentary Behavior* und einem geringen Level an moderater bis intensiver körperlicher Aktivität schien besonders kritisch für die physische Gesundheit zu sein (de Moraes et al., 2013; Santos et al., 2014; Väistö et al., 2014). Diese Befunde sprechen ebenfalls für eine gewisse Unabhängigkeit von *Sedentary Behavior* und moderater bis intensiver körperlicher Aktivität als gesundheitliche Risikofaktoren.

Mehrere Studien zeigten auch Beeinträchtigungen der psychischen Gesundheit von Kindern und Jugendlichen durch ein hohes Ausmaß an *Sedentary Behavior*. Im Fokus standen hierbei vor allem depressive Symptome, das psychische Wohlbefinden, das physische Selbstkonzept sowie der Selbstwert (Biddle & Asare, 2011; Tremblay et al., 2011; Costigan, Barnett, Plotnikoff, & Lubans, 2013). Unter statistischer Kontrolle der körperlichen Aktivität stellte sich *Sedentary Behavior* als Prädiktor unter anderem für ein schlechteres physisches Selbstkonzept (Eyal & Te'eni-Harari, 2013), eine geringere subjektive Lebensqualität (Iannotti et al., 2009) sowie eine stärker ausgeprägte depressive Symptomatik (Cao et al., 2011; Sund, Larsson, & Wichstrom, 2011) heraus. Auch hier scheinen die oben genannten kombinierten Effekte aus einem hohen Ausmaß an *Sedentary Behavior* und einem geringen Level an moderater bis intensiver körperlicher Aktivität beobachtbar zu sein (Cao et al., 2011). Erste Hinweise auf einen kausalen Zusammenhang liefern Ergebnisse von Längsschnittstudien. Beispielsweise fanden Primack, Swanier, Georgiopoulos, Land und Fine (2009), dass der Medienkonsum Jugendlicher mit der Zunahme depressiver Symptome sieben Jahre später assoziiert war. Ähnliche – zwar kleine, aber konsistente – Effekte wurden auch für die subjektive Lebensqualität (Gopinath, Hardy, Baur, Burlutsky, & Mitchell, 2012) und den Selbstwert im Jugendalter (Martins & Harrison, 2012) berichtet. Zudem könnte die Reduktion sitzender/liegender Aktivitäten eine Strategie sein, um die psychische Gesundheit zu verbessern. In einer randomisierten Kontrollgruppenstudie zeigten Goldfield et al. (2007) anhand einer Gruppe übergewichtiger Kinder mit risikoreichem Aktivitätsverhalten, dass der Rückgang des Fernsehkonsums über die Interventionsphase mit einer Verbesserung des physischen und globalen Selbstwerts assoziiert war. Im Gegensatz dazu gibt es aber auch vereinzelte Längsschnittstudien, die einen umgekehrten Zusammenhang berichteten. So zeigten beispielsweise Jugendliche mit einer stärker ausgeprägten depressiven Symptomatik ein höheres Ausmaß an sitzenden/liegenden Verhaltensweisen eineinhalb Jahre später (Schmitz et al., 2002). Das heißt, *Sedentary Behavior* und die psychische Gesundheit von Kindern und Jugendlichen könnten auch in einem bidirektionalen Zusammenhang zueinander stehen.

1.4 Interventionen zur Reduktion von *Sedentary Behavior* im Kindes- und Jugendalter

Da vor allem der Fernsehkonsum, aber auch die generelle elektronische Mediennutzung wegen ihrer hohen Prävalenz sowie ihrer Assoziation mit Übergewicht im Kindes- und Jugendalter in den Fokus der Wissenschaft geriet (Tremblay et al., 2011), verfolgten die meisten bishe-

rigen Interventionen zur Reduktion des *Sedentary Behavior* den Ansatz der Einschränkung einzelner bildschirmgebundener sitzender/liegender Verhaltensweisen beziehungsweise der gesamten Bildschirmzeit, um somit auch Probleme des Gewichtsstatus zu verringern (DeMattia, Lemont, & Meurer, 2007; Maniccia, Davison, Marshall, Manganello, & Dennison, 2011). Viele dieser Interventionen zielten auf die Verbesserung mehrere Gesundheitsverhaltensweisen ab, das heißt, neben *Sedentary Behavior* wurde häufig auch versucht, die körperliche Aktivität zu steigern und/oder das Essverhalten zu verbessern (Biddle, O'Connell, & Braithwaite, 2011; Maniccia et al., 2011). Am häufigsten wurden kognitive Strategien wie Zielsetzung, Selbstüberwachung und Problemlösen sowie verhaltensbasierte Strategien wie positive Verstärkung und kontingente Belohnung zur Verhaltensänderung genutzt (Biddle, Petrolini, & Pearson, 2014).

Entsprechend der Synthesen verschiedener Übersichtsarbeiten, die die Ergebnisse von Interventionen zur Reduktion von vorrangig bildschirmgebundenem *Sedentary Behavior* im Kindes- und Jugendalter zusammenfassten, konnte insgesamt ein kleiner, aber signifikanter Effekt gefunden werden (Biddle et al., 2014). Biddle, O'Connell und Braithwaite (2011) haben für die geringen Effekte der Interventionen verschiedene Erklärungsmöglichkeiten diskutiert. Zum einen scheint *Sedentary Behavior* ein sehr habituelles Verhalten zu sein und daher schwer zu verändern. Gerade bildschirmgebundenes sitzendes/liegendes Verhalten wie Fernsehen oder Computernutzung sind hochprävalent bei Kinder und Jugendlichen (Hardy et al., 2006), was für die hohe Attraktivität dieser Freizeitbeschäftigungen spricht. Zudem ist *Sedentary Behavior* leicht verfügbar, denn die meisten Jugendlichen haben freien Zugang zu Fernsehgeräten und Computern und/oder besitzen eigene Smartphones (Medienpädagogischer Forschungsverbund Südwest, 2014). Im Gegensatz dazu ist körperliche Aktivität für viele weniger attraktiv und mit zusätzlichem Aufwand (z. B. einen Ort aufsuchen, an dem man Sport treiben kann, oder Kleidung wechseln vor und nach dem Sport) verbunden (Epstein & Roemmich, 2001). Vor allem körperliche Aktivität mit hoher Intensität ruft bei vielen Jugendlichen negative affektive Reaktionen hervor (Schneider, Dunn, & Cooper, 2009). Als weiteren Grund für die geringeren Effekte führten Biddle, O'Connell und Braithwaite (2011) an, dass viele Interventionen auf die Reduktion einzelner bildschirmgebundener Verhaltensweisen abzielten. Dabei scheint es eher unwahrscheinlich, dass eine sitzende/liegende Beschäftigung wie beispielsweise Fernsehen komplett durch leichte oder gar moderate körperliche Aktivität ersetzt wird, sondern vermutlich eher durch andere sitzende/liegende Verhaltensweisen.

2 HERLEITUNG DER FRAGESTELLUNGEN UND ZIELSETZUNGEN

Das Jugendalter stellt sowohl hinsichtlich des bewegungsbezogenen Gesundheitsverhaltens als auch bezüglich der Vulnerabilität für Beeinträchtigungen der psychischen Gesundheit eine kritische Lebensphase dar. Während die positiven Effekte der körperlichen Aktivität auf die physische und psychische Gesundheit bisher gut bestätigt sind, stellte sich *Sedentary Behavior* zwar als unabhängiger Risikofaktor für die physische Gesundheit Jugendlicher heraus, der Zusammenhang mit der psychischen Gesundheit scheint bislang jedoch weniger eindeutig. Neben der verhältnismäßig spärlichen Studienlage scheint die Fokussierung vieler Studien auf bildschirmgebundenes *Sedentary Behavior* besonders problematisch zu sein, da sie eine klare Rückführung möglicher Beeinträchtigungen der psychischen Gesundheit auf das Sitzen/Liegen an sich nicht möglich macht. Bisherige Interventionen zur Verbesserung des bewegungsbezogenen Gesundheitsverhaltens, insbesondere der Reduktion sitzender/liegender Verhaltensweisen, scheinen nur begrenzt wirksam zu sein. Die vorliegende Dissertation knüpft daher an den offenen Themen des bisherigen Forschungsstandes an und zielt auf die Untersuchung der nachfolgend im Einzelnen hergeleiteten Fragestellungen ab.

2.1 Manuskript 1 – Systematische Übersichtsarbeit zum Zusammenhang zwischen *Sedentary Behavior* und Indikatoren der psychischen Gesundheit im Kindes- und Jugendalter

Die Untersuchung des Zusammenhangs zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter stellt ein junges und inkonsistentes Forschungsfeld dar. Es scheint besonders relevant, die aktuellen Befunde zusammenzufassen und damit Schlussfolgerungen für die Praxis und vor allem auch für die weitere Forschung formulieren zu können. Nach dem Kenntnisstand der Autorin lagen zum Zeitpunkt des Verfassens dieser Arbeit zwei Übersichtsarbeiten vor, die einem systematischen Ansatz folgend die Befundlage zu Assoziationen zwischen *Sedentary Behavior* und Indikatoren der psychischen Gesundheit im Kindes- und Jugendalter zusammenfassten. Tremblay und Kollegen (2011) beschäftigten sich neben der Beziehung von *Sedentary Behavior* und physischen beziehungsweise sozialen Gesundheitsbereichen mit dem Selbstwert als wichtigen Marker der psychischen Gesundheit. Sie schlossen in ihrer Übersichtsarbeit Studien ein, die Kinder und Jugendliche im Alter von 5 bis 17 Jahren untersuchten. Bezüglich des Selbstwerts konnten sie 14 relevante Primärstudien identifizieren. Ihre Synthese ergab einen konsistenten, wenn auch geringen, negativen Zu-

sammenhang zwischen der Zeit, die Kinder und Jugendliche mit sitzenden/liegenden, vor allem bildschirmgebundenen, Verhaltensweisen verbrachten und deren Selbstwert. Ein hohes Ausmaß an *Sedentary Behavior* war demnach mit einem niedrigeren Selbstwert assoziiert. Auch wenn Tremblay und Kollegen ein breites Altersspektrum berücksichtigten, beschränkte sich ihre Übersichtsarbeit auf den Selbstwert als lediglich einen Indikator der psychischen Gesundheit.

In einer anderen systematischen Übersichtsarbeit untersuchten Costigan et al. (2013) die Beziehung zwischen bildschirmgebundenem *Sedentary Behavior* und der Gesundheit von Mädchen im Alter von 12 bis 18 Jahren. Sie konnten sechs relevante Primärstudien finden, die Zusammenhänge mit der psychosozialen Gesundheit berichteten. Als wesentlichen Befund gaben Costigan und Kollegen eine negative Assoziation zwischen bildschirmgebundenen sitzenden/liegenden Verhaltensweisen und dem psychischen Wohlbefinden sowie eine positive Assoziation mit depressiven Symptomen an. Zwar schlossen Costigan und Kollegen verschiedene Indikatoren der psychischen Gesundheit ein, jedoch beschränkten sie ihre Übersichtsarbeit auf Studien, die bildschirmgebundenes *Sedentary Behavior* bei Mädchen im Jugendalter untersuchten.

Die vorliegende systematische Übersichtsarbeit strebt einen umfassenden Überblick zum Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter an, um daraus weiteren Forschungs- und Handlungsbedarf identifizieren zu können. Dabei soll ein erweiterter systematischer Ansatz verfolgt werden, der die Stärken beider zuvor genannten Übersichtsarbeiten integriert. Das bedeutet, dass a) ein großes Altersspektrum, b) beide Geschlechter, c) verschiedene Arten/Indikatoren von *Sedentary Behavior* sowie d) vielfältige Indikatoren der psychischen Gesundheit Berücksichtigung finden sollen.

2.2 Manuskript 2 – bildschirmgebundenes versus bildschirmungebundenes *Sedentary Behavior* und Indikatoren des psychischen Wohlbefindens im Jugendalter

Der überwiegende Teil der Studien, die sich mit dem Zusammenhang von *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter beschäftigten, nutzte einzelne bildschirmgebundene sitzende/liegende Verhaltensweisen, vor allem den Fernsehkonsum, oder einen kombinierten Wert für die gesamte Bildschirmzeit als Indikator für *Sedentary Be-*

havior. Problematisch könnte dieser Ansatz in verschiedener Hinsicht sein: Zum einen scheinen einzelne Indikatoren die Gesamtzeit des sitzenden/liegenden Verhaltens nicht adäquat abzubilden. Während beispielsweise die Fernsehzeit bei Jugendlichen in den letzten 10 Jahren zurückgegangen ist, hat die Computernutzung zugenommen (Bucksch, Inchley, Hamrik, Finne, & Kolip, 2014). Zusätzlich berichteten Biddle, Gorely und Marshall (2009) eine negative Assoziation zwischen der Fernsehzeit und der Zeit, die mit anderen sitzenden/liegenden Hobbys ohne Bildschirm, Hausaufgaben oder sozialen Aktivitäten verbracht wird. Sowohl die alleinige Erfassung eines bildschirmgebundenen Indikators als auch die gesamte Bildschirmzeit könnte zu einer Unterschätzung des *Sedentary Behavior* führen. Schließlich verbringen Jugendliche ihre Freizeit neben bildschirmgebundenen auch mit einer Reihe bildschirmungebundener sitzender/liegender Verhaltensweisen, wie beispielsweise Musik hören, lesen oder mit Freunden zusammen sein (Bauer, Friend, Graham, & Neumark-Sztainer, 2012; Zabinski et al., 2007).

Aufgrund dieser dominanten Stellung bildschirmgebundener sitzender/liegender Verhaltensweisen wie dem Fernsehkonsum oder der Computernutzung in der Forschung zu Zusammenhängen mit der psychische Gesundheit lassen sich mögliche mit dem Sitzen/Liegen per se assoziierte Prozesse nach bisheriger Befundlage nicht von Medieneinflüssen, wie beispielsweise die Orientierung an unrealistischen Schönheitsidealen, trennen. In einer explorativen Studie soll daher untersucht werden, ob es Unterschiede hinsichtlich des Zusammenhangs von *Sedentary Behavior* und Indikatoren des psychischen Wohlbefindens zwischen bildschirmgebundenen und bildschirmungebundenen sitzenden/liegenden Verhaltensweisen bei Jugendlichen gibt. Zudem sollen die Zusammenhänge zwischen *Sedentary Behavior* und den Indikatoren des psychischen Wohlbefindens unabhängig von der moderaten bis intensiven körperlichen Aktivität sowie nach dem Geschlecht getrennt betrachtet werden. Denn wie oben bereits dargestellt, zeigen sich sowohl in der Ausübung verschiedener sitzender/liegender Verhaltensweisen als auch in der Beeinträchtigung der psychischen Gesundheit Unterschiede zwischen Jungen und Mädchen.

2.3 Manuskript 3 und 4: Studienprotokoll und Ergebnisse einer

Evaluationsstudie zur Wirksamkeit der schulbasierten Intervention „läuft.“

Aufgrund der kritischen Entwicklung des bewegungsbezogenen Gesundheitsverhaltens im Jugendalter scheinen Interventionen, die einen kombinierten Ansatz verfolgen, das heißt, so-

wohl auf die Steigerung der körperlichen Aktivität als auch die Reduktion des *Sedentary Behavior* abzielen, in dieser Lebensphase besonders wichtig. Die schulbasierte Intervention „läuft.“ verfolgt hierfür einen umfassenden Ansatz zur Bewegungsförderung, der nicht nur sportliche, sondern insbesondere auch körperliche Aktivität im Alltag und von geringer Intensität einschließt. Wie bisherige Interventionsstudien im Setting Schule zeigten, ist vor allem der Transfer in den Alltag problematisch (De Meester, van Lenthe, Spittaels, Lien, & de Bourdeaudhuij, 2009; van Sluijs, McMinn, & Griffin, 2008). Außerdem scheint das Ansetzen an einzelnen sitzenden/liegenden Verhaltensweisen zu eher kleinen Effekten zu führen (Biddle et al., 2011).

Die Idee hinter der Intervention „läuft.“ ist daher in erster Linie die Förderung körperlicher Aktivität verschiedener Intensitäten und in unterschiedlichen Kontexten durch den Einsatz von Schrittzählern und klassenbasierten Wettbewerben. Es scheint einen starken inversen Zusammenhang zwischen *Sedentary Behavior* und der gesamten körperlichen Aktivität zu geben, wohingegen die Assoziation mit moderater bis intensiver körperlicher Aktivität deutlich geringer ausfällt (Ekelund et al., 2012). Demnach sollte die Steigerung leichter bis intensiver körperlicher Aktivität auch mit einer Reduktion sitzender/liegender Verhaltensweisen einhergehen. Zudem scheint die Entscheidung zugunsten von sitzenden/liegenden anstelle von körperlich aktiven Beschäftigungen auch mit der höheren Verfügbarkeit, dem geringeren Aufwand und dem höheren Spaßfaktor von sitzendem/liegendem Verhalten zusammenzuhängen (Epstein & Roemmich, 2001; Schneider et al., 2009). Durch die Implementierung von Klassenwettbewerben bei „läuft.“ soll körperliche Aktivität positiv verstärkt werden. Auch die Änderung sozialer Normen sowie die soziale Unterstützung im Klassenverband können dazu beitragen, körperliche Aktivität für die teilnehmenden Jugendlichen attraktiver zu machen. Zudem ist die Peer-Group eine wichtige Determinante des bewegungsbezogenen Gesundheitsverhaltens Jugendlicher (Silva, Lott, Mota, & Welk, 2014; Sawka, McCormack, Nettel-Aguirre, Hawe, & Doyle-Baker, 2013; de la Haye, Robins, Mohr, & Wilson, 2010). Der breite Fokus auf körperliche Aktivität, das heißt auch wenig intensive Aktivität, durch den Einsatz von Schrittzählern könnte zudem verschiedene positive Aspekte beinhalten. Neben der Reduzierung wahrgenommener Hürden für körperliche Aktivität könnte auch das Bedürfnis vieler Jugendlicher, selbst entscheiden zu wollen, wann sie wo und welcher Aktivität nachgehen, entsprochen werden (Corder, Atkin, Ekelund, & van Sluijs, 2013).

Der Einsatz von Schrittzählern als effektive Maßnahme zur Bewegungsförderung (Lubans, Morgan, & Tudor-Locke, 2009) wird hierfür mit erfolgreichen Strategien der Verhaltensänderung, nämlich Selbst-Monitoring, Zielsetzung und sozialer Unterstützung, kombiniert (Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Ory, Jordan, & Bazzarre, 2002). In einer cluster-randomisierten Kontrollgruppen-Studie sollen die unmittelbaren Effekte der Intervention „läuft.“ auf die körperliche Aktivität, das sitzende/liegende Verhalten sowie die kardiorespiratorische Fitness der Schüler/innen untersucht werden.

3 MANUSKRIPTE

3.1 Übersicht zu den Manuskripten

Nachfolgend werden die Publikationen aufgeführt, die dieser kumulativen Dissertation zugrunde liegen. Eine Übersicht zu den Eigenanteilen der Autorin an jeder der wissenschaftlichen Arbeiten ist Anhang A zu entnehmen.

Manuskript 1

Suchert, V., Hanewinkel, R., & Isensee, B. (2015). Sedentary behavior and indicators of mental health in school-aged children and adolescents: a systematic review. *Preventive Medicine, 76*, 48-57. doi: 10.1016/j.ypmed.2015.03.026

Manuskript 2

Suchert, V., Hanewinkel, R., Isensee, B., & läuft. Study Group (2015). Sedentary behavior, depressed affect, and indicators of mental well-being in adolescence: Does the screen only matter for girls? *Journal of Adolescence, 42*, 50-58. doi: 10.1016/j.adolescence.2015.03.014

Manuskript 3

Suchert, V., Isensee, B., Hansen, J., Johannsen, M., Krieger, C., Müller, K., Sauer, I., Weisser, B., Sargent, J. D., & Hanewinkel, R. (2013). "läuft." - a school-based multi-component program to establish a physically active lifestyle in adolescence: study protocol for a cluster-randomized controlled trial. *Trials, 14*(1), 416. doi: 10.1186/1745-6215-14-416

Manuskript 4

Suchert, V., Isensee, B., Sargent, J., Weisser, B., Hanewinkel, R., & läuft. Study Group (2015). Prospective effects of pedometer use and class competitions on physical activity in youth: a cluster-randomized controlled trial. *Preventive Medicine, 81*, 399-404. doi: 10.1016/j.ypmed.2015.10.002.

3.2 Manuskript 1 – Systematische Übersichtsarbeit zum Zusammenhang zwischen *Sedentary Behavior* und Indikatoren der psychischen Gesundheit im Kindes- und Jugendalter

Sedentary behavior and indicators of mental health in school-aged children and adolescents: a systematic review

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Abstract

Objective: The presented systematic review aims at giving a comprehensive overview of studies assessing the relationship between sedentary behavior and indicators of mental health in school-aged children and adolescents.

Methods: Six online databases (MEDLINE, EMBASE, PsycINFO, PsycARTICLES, CINAHL and SPORTDiscus) as well as personal libraries and reference lists of existing literature were searched for eligible studies.

Results: Ninety-one studies met all inclusion criteria. There was strong evidence that high levels of screen time were associated with more hyperactivity/inattention problems and internalizing problems as well as with less psychological well-being and perceived quality of life. Concerning depressive symptoms, self-esteem, eating disorder symptoms, and anxiety symptoms, no clear conclusion could be drawn. But, taking quality assessment into account, self-esteem was negatively associated with sedentary behavior, i.e. high levels of time engaging in screen-based sedentary behavior were linked to lower scores in self-esteem.

Conclusions: Overall, the association between sedentary behavior and mental health indicators was rather indeterminate. Future studies of high quality and with an objective measure of sedentary behavior will be necessary to further examine this association as well as to investigate longitudinal relationships and the direction of causality. Furthermore, more studies are needed to identify moderating and mediating variables.

Keywords: Sedentary lifestyle, mental health, child, adolescent, systematic review

Introduction

Considering the importance of electronic entertainment such as TV, video games or computers and inactive modes of transportation in developed societies, the investigation of adverse effects of an increasing sedentary lifestyle has become a new public health issue. About 10 years ago, the term sedentary behavior (SB) was often used to describe a lack of physical activity including also activities of low intensity (Pate et al., 2008). But in contrast to physical inactivity, SB is defined more appropriately as a distinct behavioral category comprising exclusively activities that do not substantially increase energy expenditure compared to resting level (Sedentary Behaviour Research Network, 2012; Pate et al., 2008). In the past few years, the amount of time spent in SB has emerged as an important and independent risk factor for children's and adolescents' physical health, additionally to the level of physical activity. Higher levels of SB, especially screen-based, were linked to higher risk for overweight and abdominal adiposity (Mitchell et al., 2013; Byun et al., 2012), decreased cardiorespiratory fitness (Mitchell et al., 2012; Santos et al., 2013) and increased cardio-metabolic health-risk (Carson and Janssen, 2011a; Byun et al., 2012; Ekelund et al., 2006). Less is known about the association between SB and mental health in youth even though beneficial impacts of physical activity and fitness on mental health are well established (World Health Organization, 2010; Biddle and Asare, 2011; Ahn and Fedewa, 2011), including lower levels of depression (Rieck et al., 2013; Wiles et al., 2012), higher self-esteem (Strauss et al., 2001) and lower levels of subjective stress (Norris et al., 1992). As stated in a recent report of the World Health Organization (WHO), about 20% of adolescents experience a mental health problem in any given year (World Health Organization, 2012). Moreover, first signs of most mental disorders occur in childhood and adolescence and persist into adulthood (Kessler et al., 2005; Belfer, 2008). Therefore, maintaining and improving mental health among children and adolescents is of considerable public health relevance (Patel et al., 2007).

To the authors' present knowledge, there are two systematic reviews examining the association between SB and mental health in childhood and/or adolescence. Tremblay and colleagues (2011) determined the relationship between SB and self-esteem (among other physical health indicators) in young people aged 5 to 17 years. As a common finding of the 14 included primary studies, they reported an inverse association. Adolescents spending a lot of time sedentary, especially with screen-based activities, were more likely to report lower levels of self-esteem. Even though Tremblay and colleagues included studies with a wide range of age and different sedentary activities, their review was limited to self-esteem as only one indicator of mental health. Another review by Costigan et al. (2013) examined the relationship between screen-based SB and health indicators in adolescent girls. With regard to psychosocial health, the authors identified six studies which found screen-based SB to be negatively associated with psychological well-being and positively with depression. Costigan et al. limited their review to adolescent girls and considered only time spent with screen-based SB.

In consideration of the high prevalence of sedentary lifestyles in modern societies and the growing body of research dealing with adverse mental health effects of SB, the present systematic review aims at giving a comprehensive overview of the existing literature. It follows an extended systematic approach that integrates different aspects and strengths of these previous reviews, namely (1) a wide range of age, (2) both genders, (3) all types of SB, and (4) different mental health outcomes.

Methods

The presented systematic review is in compliance with the PRISMA Statement (Liberati et al., 2009).

Eligibility criteria

Studies dealing with the relationship between SB and mental health in youth, and meeting the following requirements were included:

(1) *Population of interest*: School-aged children and adolescents (both genders) aged 5 to 18 years. Also studies investigating a larger range of age were eligible if the relevant age group was analyzed and reported separately.

(2) *Study design*: Cross-sectional, longitudinal and experimental.

(3) *Publication status*: Published in peer-reviewed journal articles.

(4) *Measure of sedentary behavior*: Included studies had to report how SB was assessed.

Both, composite scores of overall SB as well as particular sedentary activities, were included.

Studies defining SB as levels of physical activity below recommendation guidelines were excluded. Active electronic gaming was no eligible measure, since it has been shown to include energy expenditure similar to light and moderate physical activity, respectively (Foley and Maddison, 2010). Studies that focused on the content viewed during screen-based sedentary activities (e.g. violence) rather than the amount of time spent with these activities were excluded as well. In addition, studies considering the prevalence of internet and/or video game addiction, or pathological internet use were not included in the review, since it is not possible to make a clear distinction between risk factor and mental health outcome.

(5) *Measure of mental health*: Based on the WHO definition of health (World Health Organization, 2002), mental health referred in this review to both: psychopathological symptoms/syndromes as well as psychological well-being.

(6) *Language limitations*: Published in English or German.

Search strategy

A systematic search of six electronic databases of all publication years (through October 31, 2013) was conducted. MEDLINE and EMBASE were searched via Ovid and PsycINFO, PsycARTICLES, CINAHL as well as SPORTDiscus via EBSCO. The search strategy was developed by one researcher (VS) and rechecked by another (BI). All search strategies can

be found in Additional File 1. Different text words as well as appropriate subject headings of each database were combined for the major topics “sedentary behavior”, “mental health” and “children and/or adolescents”. The searches were limited to human studies published in peer-reviewed journals. All studies identified by the search strategy were imported into Reference Manager 12 (Thomson Reuters, New York, USA). After duplicates had been removed a single reviewer screened title and abstract of each study for eligibility. In cases if (1) a study was evaluated as meeting initial screening or (2) it was uncertain whether a paper was relevant for the review, full texts were obtained. Full texts of further articles that might be appropriate, and were known to the author or identified by manually screening reference lists of other reviews were also taken to the next step. Finally, on the basis of study selection criteria full text articles were assessed for inclusion independently by two reviewers (VS, BI). Discrepancies were discussed and resolved.

Data extraction

Data extraction was conducted and managed using Microsoft Access 2010 (Microsoft Corporation, Redmond, USA). Data extraction was carried out by a single reviewer (VS) regarding general information about each study, study characteristics, participant characteristics, measurement of sedentary behavior and mental health, whether results were adjusted for physical activity and criteria for quality assessment.

Risk of bias and quality assessment

An assessment of study design was used as a global marker of quality as suggested by the Centre for Reviews and Dissemination (Centre for Reviews and Dissemination, 2009). Additionally, an adapted version of the Newcastle-Ottawa Scale was used (Wells et al., 2014). This tool consists of eight items including quality aspects of selection, comparability and outcome. Each item was scored with one or two points and summed up to a total score. These summed scores were grouped into high (0-3), moderate (4-6), and low (7-9) risk of bias. The whole scale is available in Additional File 2.

Data synthesis

The primary studies were rated as “+” or “-“ depending on the direction of association if a significant association between sedentary behavior and mental health was reported, and as “0” if there was no association. In cases where associations in boys and girls were different the study was coded twice and included in data synthesis separately for both subsamples. As reported in other reviews, to summarize findings of the primary studies, evidence ratings were based on the number of studies supporting a particular association and were coded as “0” (no association) if 0% - 33% of the findings supported the association, as “?” (indeterminate association) if 34% - 59% of the findings supported the association, as “+” (positive association) and “-“ (negative association), respectively, if 60% - 100% of the findings supported the association (Costigan et al., 2013; Hinkley et al., 2008; Sallis et al., 2000). To take risk of bias assessment into account, an additional coding was applied if 4 or more high quality studies supported the association.

Results

Overview of studies

After all duplicates were removed a total of 5,272 studies were identified through searching electronic databases. Additional 10 studies were added from reference lists or the author’s personal literature database. In Figure 1, a detailed flow chart of primary studies is presented. Screening titles and abstracts of these articles led to the exclusion of 5,085 studies, i.e. full texts of 187 studies were obtained. Ninety-six articles were excluded. The most frequent reasons for exclusion: 1) no adequate indicator for mental health or SB, 2) no information about the association between SB and indicators of mental health, and 3) an inappropriate age range. Ninety-one studies met all inclusion criteria. The majority were cross-sectional studies (N=73) and investigated both genders (N=81). Table 1 provides characteristics of all studies included in the review. Eleven studies adjusted the association between SB and mental health indicators for physical activity (Chen et al., 2005; Dalton, III et al., 2011; Dumith et al., 2010; Eyal and Te'eni-Harari, 2013; Iannotti et al., 2009; Nihill et al.,

2013; Page et al., 2010; Racine et al., 2011; Sund et al., 2011; Tin et al., 2012; Webb et al., 2013), and only four assessed SB objectively through accelerometers (Hume et al., 2011; Johnson et al., 2008; Nihill et al., 2013; Page et al., 2010). Outcome measures were grouped into seven categories: depression symptoms, internalizing problems, anxiety symptoms, self-esteem, eating disorder symptoms, hyperactivity/inattention problems, and well-being and quality of life.

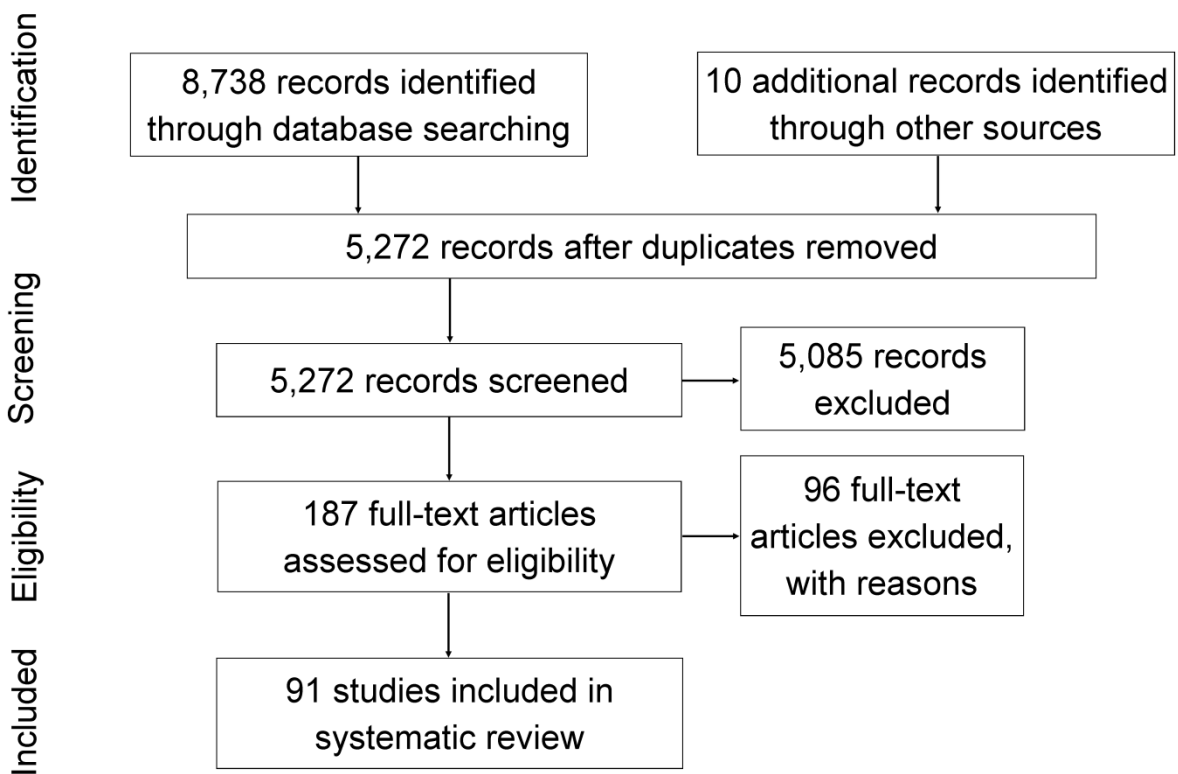


Figure 1: Flow of study selection through the phases of the review

Risk of bias

The total scores for risk of bias assessment ranged from 2 to 8 ($M=5.69$; $SD=1.54$). Ten studies were scored as high risk of bias, 49 studies as moderate risk of bias, and 32 studies as low risk of bias. The overall level of evidence for all outcome domains is scored as three, since included studies used a cross-sectional design in large part. There were only a few prospective cohort studies and randomized controlled trials.

Table 1: Characteristics of studies included in the review

Primary author and year	Study design	Sample size	Gender (% male)	Age		M (SD)	Sedentary behavior	Mental health indicator	PA adj.	Risk of bias
				Range	M (SD)					
Allahverdipour et al. (2010)	Cross-sectional	444	Both (49%)	12-15			GAMES	DEP, ANX		7
Anton et al. (2006)	Cross-sectional	45	Both (51%)	11-13	11.7 (0.6)		ST	DEP		3
Benson et al. (2013)	Cross-sectional	117	Both (37.6%)	7-17	12.4 (2.89)		ST	DEP		5
Borras et al. (2011)	Cross-sectional	302	Both (50%)	10-12	Girls: 10.7 (3.1) Boys: 11.6 (1.01)		ST	WB		4
Borzekowski et al. (2000)	Cross-sectional	837	Only girls		14.9 (0.47)		ST	EDS		6
Botta (2000)	Cross-sectional	178	Only girls		15.28 (1.12)		TV	EDS		4
Brodersen et al. (2005)	Cross-sectional	4320	Both (59.7%)	11-12	Girls: 11.84 (0.32) Boys: 11.81 (0.37)		ST	WB, ADHD, INTERN		7
Calado et al. (2010)	Cross-sectional	1115	Both (49.1%)	14-16			TV	EDS		7
Cao et al. (2011)	Cross-sectional	5003	Both (52.1%)	11-16	13.2 (1.0)		ST	DEP, ANX		7
Chan et al. (2006)	Cross-sectional	72	Both (56.9%)		15.3 (0.7)		GAMES, INT, TV	ADHD		5
Chen et al. (2005)	Longitudinal	7794	Both (49,6%)	t1: 9-10 t2: 12-13	t1: 9.7 t2: 12.8		TV	QOL	x	8
Chen et al. (2008)	Cross-sectional	660	Both (53.2%)	13-18	15.03 (1.74)		TV, GA-MES	QOL		5

Author (Year)	Study Design	N	Both (%)	Age Group	Mean (SD)	Outcomes	Level
Chen et al. (2009)	Longitudinal	10347	Both (49.6%)	11 th to 12 th grade		TV, GAMES, DEP	5
Colwell et al. (2000)	Cross-sectional	204	Both (44.6%)	12-14	12.7	GAMES SE	3
Colwell et al. (2003)	Cross-sectional	305	Both (52.1%)	12-13		GAMES SE	3
Comer et al. (2008)	Cross-sectional	90	Both (52.2%)	7-13	10.78 (2.0)	TV, INT ANX	4
Coyne et al. (2011)	Cross-sectional	287	Both (65%)	11-16	13.26 (1.05)	GAMES INTERN	6
Dalton et al. (2011)	Cross-sectional	152	Both (46.1%)	11-12	11.8	ST QOL	6
Do et al. (2013)	Cross-sectional	136589	Both (52.3%)	13-18		INT DEP	7
Dominick (1984)	Cross-sectional	250	Both (44%)	10 th to 11 th grade		TV, GAMES SE	4
Dumith et al. (2010)	Cross-sectional	4431	Both	11		ST WB	7
Durkin et al. (2002)	Cross-sectional	1304	Both	ca. 16		GAMES DEP, SE	6
Eyal et al. (2013)	Cross-sectional	391	Both (46.5%)	12-15	13.13 (0.7)	ST EDS	6
Ferguson (2011)	Cross-sectional	603	Both (51.2%)	10-14	12.35 (1.34)	ST ADHD	6
Fling et al. (1992)	Cross-sectional	153	Both (68.0%)	11-18		GAMES SE	2
Forrest et al. (2008)	Cross-sectional	13857	Both (50.5%)	9 th to 12 th grade		TV, GAMES EDS	6
Fouts et al. (2002)	Cross-sectional	189	Only girls	10-17	13.6	TV EDS	4
Fulkerson et al. (2004)	Cross-sectional	4734	Both (50.2%)		Girls: 14.7 (1.7) Boys: 14.9 (1.7)	TV DEP	7
Goldfield et al. (2007)	RCT	30	Both (43.3%)	8-12	t1: 10.0 (0.9) t2: 10.7 (1.4)	TV SE, EDS	6
Gopinath et al. (2012)	Longitudinal	1094	Both (43.9%)	T1: 12-13 T2: 17-18	T1: 12.7 T2: 17.3 (0.6)	ST, SB QOL	7
Gross et al. (2002)	Cross-sectional	130	Both (37.7%)	11-13	12.11 (0.40)	INT DEP, ANX, WB	4

Hargborg (1995)	Cross-sectional	152	Both	9 th to 10 th grade	TV	SE	5
Harman et al. (2005)	Cross-sectional	187	Both (42%)	11-16	INT	SE, ANX	5
Harrison (2000a)	Cross-sectional	303	Both (56%)	7.45 (1.02)	TV	EDS	4
Harrison (2000b)	Cross-sectional	366	Both (50.3%)	6 th grade: 11.5 9 th grade: 14.6 12 th grade: 17.8	TV	EDS	5
Holder et al. (2009)	Cross-sectional	514	Both (49%)	8-12	TV, COMP, GAMES	EDS, WB	4
Holtz et al. (2011)	Cross-sectional	205	Both (48.8%)	10-14	INT, GAMES	INTERN	6
Hong et al. (2009)	Cross-sectional	2444	Both (48.3%)	13.85 (1.04)	TV, NSB	DEP	8
Hume et al. (2011)	Longitudinal	155	Both (40%)	Girls: 14.4 (0.57) Boys: 14.5 (0.64)	TV, SB	DEP	7
Iannotti et al. (2009)	Cross-sectional	49124	Both	11-15	ST	EDS, QOL	8
Jackson et al. (2010)	Cross-sectional	500	Both (47%)	11-16	INT, GAMES	EDS, SE	5
Johnson et al. (2008)	Cross-sectional	1397	Only girls	12.0 (0.50)	SB	DEP	7
Katon et al. (2010)	Cross-sectional	2291	Both (50.5%)	13-17	COMP, TV	DEP	7
Kim (2012)	Cross-sectional	75066	Both (52.8%)	7 th to 12 th grade	INT	DEP	7
Lacy et al. (2012)	Cross-sectional	3040	Both (56%)	Girls: 14.7 (1.4) Boys: 14.6 (1.3)	ST	QOL	7
Landhuis et al. (2007)	Longitudinal	1037	Both (51.6%)	5-11	TV	ADHD	6
Leatherdale et al. (2011)	Cross-sectional	51922	Both (48.7%)	6 th to 12 th grade	ST, TV, GAMES, COMP	SE	6
Levine et al. (2000)	Cross-sectional	70	Both (47.1%)	8-11	TV	ADHD	3

Lingineni et al. (2012)	Cross-sectional	68634	Both (52.0%)	5-17		TV, COMP	ADHD	7
Lohaus et al. (2005)	Cross-sectional	357	Both (43.7%)	10-14	11.1 (0.59)	SB	INTERN	3
Martins et al. (2012)	Longitudinal	429	Both (48.0%)	T1: 7-12 T2: 8-13	T1: 8.72 (1.02) T2: 9.75 (1.03)	TV	SE	7
McClure et al. (2010)	Cross-sectional	4458	Both (50.1%)	10-16	14.08 (1.39)	TV	SE	7
McHale et al. (2001)	Longitudinal	198	Both (48.5%)		T1: 10.9 (0.54)	NSB, TV	DEP	5
McHale et al. (2009)	Cross-sectional	469	Both (49%)		12.8 (0.58)	TV, NSB	DEP	5
McWilliams et al. (2013)	Cross-sectional	424	Both (38%)	9-10		SB	ADHD	6
Mesch (2006)	Cross-sectional	396	Both (61.4%)	13-18	15.5 (1.66)	INT	SE	7
Messias et al. (2011)	Cross-sectional	13817	Both (50.3%)	14-18	16.1 (1.2)	COMP, GAMES	DEP	8
Moriarty et al. (2008)	Longitudinal	350	Both (47.4%)	14-18	16.1 (1.2)	COMP, GAMES	DEP	
Nakamura et al. (2012)	Cross-sectional	3464	Both (49.7%)	10-12	t1: 8.75 (1.02) t2: 9.78 (1.06)	TV	EDS	6
Neumark-Sztainer et al. (2004)	Cross-sectional	4746	Both (50.2%)	11-18	10.05 (0.81)	ST	DEP	6
Nihill et al. (2013)	Cross-sectional	357	Only girls		14.9	TV	EDS	6
Ohannessian (2009)	Longitudinal	328	Both (42%)	14-16	13.2 (0.5)	ST, SB	EDS, SE	8
Özmerit et al. (2002)	Cross-sectional	689	Both (49.8%)		t1: 14.99 (0.70)	TV, GAMES, INT	DEP, ANX	6
Page et al. (2010)	Cross-sectional	1013	Both (46.1%)	10-11	7.95 (0.77)	TV	INTERN, ADHD	6
					10.95 (0.41)	SB, TV, COMP	WB	8

Pantic et al. (2012)	Cross-sectional	160	Both (31.9%)	18.02 (0.29)	TV	DEP	4
Parkes et al. (2013)	Longitudinal	11014	Both (48.9%)	t1: 5; t2: 7	ST	INTERN, ADHD	7
Racine et al. (2011)	Cross-sectional	1027	Only girls	3 rd to 5 th grade	ST	SE, EDS	x 8
Robinson et al. (2003)	RCT	61	Only girls	8-10	TV, GAMES	SE, EDS	5
Robinson et al. (2011)	Cross-sectional	1598	Both (51.3%)	14.01 (0.20)	ST	INTERN	7
Russ et al. (2009)	Cross-sectional	54863	Both (51%)	6-17	ST	SE	6
Sanders et al. (2000)	Cross-sectional	89	Both (41.6%)	High school seniors	INT	DEP	4
Schmitz et al. (2002)	Longitudinal	3845	Both (51.0%)	11-15	ST	DEP	6
Schooler et al. (2011)	Longitudinal	577	Both (44.5%)	t1: 11-17	TV	EDS	6
Selfhout et al. (2009)	Longitudinal	307	Both (48.9%)	t1: 14-17	INT	DEP, ANX	5
Singer et al. (1998)	Cross-sectional	2245	Both (50.9%)	11 (1.8)	TV	ANX	5
Stroman (1986)	Cross-sectional	102	Both (39%)	7-13	TV	SE	3
Subervi-Velez et al. (1990)	Cross-sectional	117	Both (40.2%)	4 th to 6 th grade	TV	SE	3
Subrahmanyam et al. (2007)	Cross-sectional	156	Both (50%)	15-18	INT	DEP	4
Sun et al. (2005)	Cross-sectional	2373	Both (47%)	11-16	INT	DEP	5
Sund et al. (2011)	Longitudinal	2360	Both (49.5%)	t1: 12-15 t2: 13-17	SB	DEP	x 8
Swing et al. (2010)	Longitudinal	1323	Both (47%)	6-12	ST, TV, GAMES	ADHD	7
Tiggemann et al. (1996)	Cross-sectional	94	Only girls	15.5 (0.56)	TV	EDS	3
Tin et al. (2012)	Cross-sectional	70210	Both (49%)	9.87 (0.63)	TV	SE	x 8
Tucker (1987)	Cross-sectional	406	Only boys	15.7 (1.2)	TV	SE	4
Ussher et al. (2007)	Cross-sectional	2623	Both (52.8)	13-16	ST	WB	6

Van Egmond-Fröhlich et al. (2012)	Cross-sectional	9428	Both	6-17	TV	ADHD	7
Webb et al. (2013)	Cross-sectional	238	Only girls	14-15	SB	SE, EDS	x 6
Wiggins (1987)	Cross-sectional	483	Both (52.2%)	4 th to 12 th grade	TV	SE	3
Willoughby (2008)	Longitudinal	1591	Both (50%)	T1: 14-82 (0.82) T2: 16.49 (0.68)	GAMES, INT	WB	5
Yang et al. (2013)	Cross-sectional	10829	Both (50.5%)	10-12	TV, COMP, GAMES, INT	DEP	7
Ybarra et al. (2005)	Cross-sectional	1501	Both (52%)	10-17	INT	DEP	8

^aUS, Canada, Switzerland, Netherlands, Czech Republic, Poland, Finland, Norway, Italy, Spain

ADHD, /hyperactivity/inattention problems; ANX, anxiety symptoms; COMP, using a computer; DEP, depressive symptoms; EDS, eating disorder symptoms; GAMES, playing video and/or computer games; INT, using the internet; INTERN, internalizing problems; M, mean; NSB, non-screen-based sedentary behaviors such as reading or study time; PA adj., adjusted for physical activity; QOL, quality of life; SB, composite score of diverse sedentary behaviors (also non-screen-based) or sedentary behavior measured via accelerometers; SD, standard deviation; SE, self-esteem; ST, screen time (composite score of at least two screen-based activities); TV, watching television; WB, well-being

Data synthesis*Depressive symptoms*

Twenty-eight studies assessed the relationship between SB and depressive symptoms. Regarding quality assessment, one study was scored as high, 14 as moderate and 13 as low risk of bias (M=6.00; SD=1.44).

Longitudinal effects of SB on depressive symptoms were examined by six studies. Two found no predictive main effect of adolescents' screen time on depressive symptoms one year later (Ohannessian, 2009; Selfhout et al., 2009). However, there was a significant interaction between the time spent watching TV and gender. Girls with the highest levels of TV viewing reported the highest level of depressive symptoms while boys with the highest level of TV viewing reported the lowest level of depressive symptoms (Ohannessian, 2009). In one study SB was a significant predictor for depressive symptoms one and a half year later (Sund et al., 2011) and in additional two studies these predictive effects were limited to the time spent playing video games, studying or reading (Chen and Lu, 2009; McHale et al., 2001). Results of one study, that aimed to predict accelerometer measured SB in late adolescence by depressive symptoms in early adolescence, failed significance (Hume et al., 2011). In contrast, screen time in early adolescence was predicted by depressive symptoms measured half a year ago (Schmitz et al., 2002).

Eight of the 21 cross-sectional studies showed no relationship between depressive symptoms and diverse measures of SB (Allahverdipour et al., 2010; Fulkerson et al., 2004; Gross et al., 2002; Hong et al., 2009; McHale et al., 2009; Pantic et al., 2012; Subrahmanyam and Lin, 2007; Sanders et al., 2000). While one study reported a small but negative association between objectively measured SB and depressive symptoms (Johnson et al., 2008), eight studies found that students with the highest levels of screen time (single measures or composite score) were those with the highest scores in depressive symptoms (Anton et al., 2006; Benson et al., 2013; Cao et al., 2011; Messias et al., 2011; Nakamura et al., 2012; Sun et al., 2005; Yang et al., 2013; Katon et al., 2010). In one study this result was limited to girls (Ybarra et al., 2005).

In three studies the relationship between using the internet or playing video games, and depressive symptoms followed a curvilinear u-shaped trend, i.e. students reporting a moderate amount of time engaging in these sedentary activities reported the lowest scores of depressive symptoms (Do et al., 2013; Durkin and Barber, 2002; Kim, 2012).

The overall data synthesis revealed an indeterminate association between SB, and depressive symptoms (Table 2).

Anxiety symptoms

Eight studies investigated the relationship between screen-based SB and anxiety symptoms ranging from moderate to low risk of bias ($M=5.38$; $SD=1.19$).

While one of the two longitudinal studies found a predictive effect of adolescents' internet use and video game play on anxiety symptoms one year later (Ohannessian, 2009), another longitudinal study could not confirm this prediction (Selfhout et al., 2009). In three cross-sectional studies the association between internet use or watching TV, and anxiety symptoms was not significant (Comer et al., 2008; Gross et al., 2002; Harman et al., 2005), but the amount of time spent watching TV was positively related to trauma symptoms (Singer et al., 1998), and screen time to anxiety symptoms (Cao et al., 2011). In another study, a u-shaped association between the time spent playing video games and anxiety symptoms was found (Allahverdipour et al., 2010).

An indeterminate association between SB and anxiety symptoms was concluded (Table 2).

Internalizing problems

Seven studies examined the association between SB and internalizing problems. One study was of low quality, and three studies were each scored as moderate and high quality ($M=6.00$; $SD=1.41$).

Only one study employed a longitudinal design, and found screen time to be a significant predictor for emotional problems two years later (Parkes et al., 2013). While one cross-sectional study found no relationship between the time children spent watching TV and

internalizing problems (Özmert et al., 2002), the other five cross-sectional studies revealed a positive association (Brodersen et al., 2005; Coyne et al., 2011; Holtz and Appel, 2011; Lohaus et al., 2005; Robinson et al., 2011). However, findings of two studies were limited to boys (Coyne et al., 2011; Lohaus et al., 2005) and results of one study to girls (Brodersen et al., 2005).

Overall, a positive association was concluded (Table 2).

Self-esteem

Twenty-four studies were identified assessing the association between SB and self-esteem. Six studies were scored as high, twelve studies as moderate, and six studies as low risk of bias ($M=5.22$; $SD=1.83$).

A number of cross-sectional studies found no significant association between single indicators of screen-based SB or a composite score of SB, and self-esteem (Webb et al., 2013; Colwell and Payne, 2000; Colwell and Kato, 2003; Fling et al., 1992; Hargborg, 1995; Harman et al., 2005; Holder et al., 2009; Mesch, 2006; Subervi-Velez and Necochea, 1990; Wiggins, 1987).

While there was one intervention study in which an increase in physical activity and a reduction of time spent watching TV did not lead to significant improvements in self-esteem (Robinson et al., 2003), in another randomized controlled trial a reduction of TV viewing led to increased self-esteem at follow-up (Goldfield et al., 2007). In a longitudinal study, weekly TV viewing was no predictor for self-esteem one year later, even though a cross-sectional negative association could be found (Martins and Harrison, 2012). This negative relationship between screen time and self-esteem was consistent with findings of eight other cross-sectional studies (Nihill et al., 2013; Leatherdale and Ahmed, 2011; McClure et al., 2010; Racine et al., 2011; Russ et al., 2009; Tucker, 1987; Dominick, 1984; Jackson et al., 2010; Durkin and Barber, 2002; Tin et al., 2012), while one of them was limited to boys (Dominick, 1984). In addition, one study found screen time but not SB measured by accelerometers negatively related to self-esteem (Nihill et al., 2013). In contrast, one study found watching

TV to be positively related to girls overall self-concept (Stroman, 1986). There were two studies indicating an inverted u-shaped association, i.e. children and adolescents reporting a moderate use of video games or TV showed the highest score of self-esteem (Durkin and Barber, 2002; Tin et al., 2012).

Based on overall data synthesis, an indeterminate association between SB and self-esteem was indicated even though this conclusion varies by the quality of the studies (Table 2). Four of the high quality studies reported higher levels of SB, at least screen time, being related to less self-esteem.

Eating disorder symptoms

Twenty studies reported the association between SB and eating disorder symptoms. In this section, eating disorder symptoms like drive for thinness, body dissatisfaction and physical self-concept are collectively treated as eating disorder symptoms. There were four studies scored as low, 15 studies as moderate, and one study as high risk of bias ($M=5.65$; $SD=1.42$).

Seven cross-sectional studies found no association between SB and eating disorder symptoms at all (Borzekowski et al., 2000; Botta, 2000; Fouts and Vaughan, 2002; Racine et al., 2011; Tiggemann and Pickering, 1996; Jackson et al., 2010; Nihill et al., 2013).

Two cluster-randomized controlled trials were intended to enhance physical activity and decrease the time spent watching TV and/or playing video games, and led to an increase of physical self-worth (Goldfield et al., 2007) and a reduction of overconcerns about weight and shape among girls (Robinson et al., 2003). Two studies investigated longitudinal effects. The time spent watching TV was no predictor for body dissatisfaction two years later (Schooler and Trinh, 2011). In contrast, TV viewing in childhood was a significant predictor for eating disorder symptoms one year later in girls but not in boys (Moriarty and Harrison, 2008).

Nine cross-sectional studies indicated a positive relationship between SB, mostly screen-based, and eating disorder symptoms. While the results of two studies were limited to girls (Harrison, 2000b; Webb et al., 2013) and of two studies to boys (Calado et al., 2010;

Neumark-Sztainer et al., 2004), five studies found a consistent positive association for both genders (Eyal and Te'eni-Harari, 2013; Harrison, 2000a; Iannotti et al., 2009; Forrest and Forrest, 2008; Holder et al., 2009).

Data synthesis revealed an indeterminate association between SB and eating disorder symptoms (Table 2).

Inattention and hyperactivity problems

Eleven studies investigated the relationship between SB, and inattention and hyperactivity problems. Except one study that was identified as high risk of bias, all studies were scored as moderate or low risk of bias ($M=6.09$; $SD=1.22$).

Three studies employed a longitudinal design suggesting a causal relationship. Childhood screen time was a significant predictor for hyperactivity/inattention problems 1 and 2 years later, respectively (Parkes et al., 2013; Swing et al., 2010). In addition, the time spent watching TV in childhood predicted inattention problems in adolescence (Landhuis et al., 2007).

In seven of eight cross-sectional studies at least one indicator of SB was positively associated with hyperactivity/inattention problems (Brodersen et al., 2005; McWilliams et al., 2013; Özmert et al., 2002; Levine and Waite, 2000; van Egmond-Frohlich et al., 2012; Lingineni et al., 2012; Chan and Rabinowitz, 2006), and one revealed no association (Ferguson, 2011).

Data synthesis (Table 2) revealed a strong positive association between the amount of SB, and hyperactivity/inattention problems.

Well-being and quality of life

Fourteen studies assessed the relationship between SB and quality of life or well-being.

Study quality was moderate to high with risk of bias assessment scores ranging from four to eight ($M=6.14$; $SD=1.51$).

The majority of studies used a composite score for screen time covering the time spent in more than one screen-based SB. Nine studies reported SB to be negatively related to quality of life or well-being (Chen et al., 2008; Chen et al., 2005; Dalton, III et al., 2011; Dumith et al., 2010; Gopinath et al., 2012; Holder et al., 2009; Iannotti et al., 2009; Lacy et al., 2012; Ussher et al., 2007). In one study this finding was limited to girls (Brodersen et al., 2005). In another study this negative relationship was only found for TV and computer use but not for objectively measured SB (Page et al., 2010), and three studies found no association at all (Borras et al., 2011; Gross et al., 2002; Willoughby, 2008). One of the latter studies employed a longitudinal design. The authors aimed to examine the prediction of adolescents' internet and video game use in late high school by their well-being in early high school (Willoughby, 2008). Two studies investigated longitudinal predictions in the opposite direction. Children watching three or more hours a day TV at 9 or 10 years of age showed an increased risk for poor quality of life 3 years later irrespectively of their physical activity level (Chen et al., 2005). Students remaining in the highest tercile of screen time over a period of five years reported less quality of life compared to those remaining in the other terciles (Gopinath et al., 2012).

Data synthesis, as presented in Table 2, suggests a strong negative association between SB and well-being or quality of life.

Discussion

The presented systematic review aimed to provide a comprehensive summary of the existing literature assessing the association between sedentary behavior (SB) and indicators of mental health in childhood and adolescence. There was strong evidence that high levels of screen time were associated with more inattention and hyperactivity problems as well as internalizing problems, and with less psychological well-being and perceived quality of life. Concerning depressive symptoms, self-esteem, eating disorder symptoms and anxiety symptoms, no clear conclusion could be drawn. But, taking quality assessment into account, self-esteem was negatively associated with SB, i.e. high levels of time engaging in screen-

based SB were linked to lower scores in self-esteem. Results of high quality studies investigating depressive symptoms are inconsistent.

Studies included in the systematic reviews by Tremblay et al. (2011) and Costigan et al.(2013) examined mainly the association between screen-based SB and physical health outcomes. Even though only a small number assessed relationships to mental health indicators, their major findings are consistent with the presented evidence above. In contrast to the examined indeterminate relationship between SB and self-esteem in the current review, Tremblay and colleagues reported a consistent negative association. These divergences might be due to stricter inclusion regarding the measure of self-esteem in the respective section of this review. In addition, inconsistent results for several mental health indicators might be due to uncertain factors interacting with SB. As seen in the results section, some studies revealed significant associations only for girls/boys.

Table 2: Results of data synthesis

Mental health indicator	Association	Studies (Primary author, publication year)	Summary coding	Quality coding
Depressive symptoms	No	Allahverdipour, 2010; Fulkerson, 2004; Gross, 2002; Hong, 2009; Hume, 2011; McHale, 2009; Pantic, 2012; Sanders, 2000; Selfhout, 2009; Subrahmanyam, 2007; Ybarra, 2005 (boys)		
	Positive	Anton, 2006; Benson, 2013; Cao, 2011; Chen, 2009; Do, 2013; Durkin, 2002; Katon, 2010; Kim, 2012; McHale, 2001; Messias, 2011; Nakamura, 2012; Ohannessian, 2009 (girls); Schmitz, 2002; Sun, 2005; Sund, 2011; Yang, 2013; Ybarra, 2005 (girls)	?	++/00
	Negative	Johnson, 2008; Ohannessian, 2009 (boys)		
Anxiety symptoms	No	Comer, 2008; Gross, 2002; Harman, 2005; Selfhout, 2009		
	Positive	Allahverdipour, 2010; Cao, 2011; Ohannessian, 2009; Singer, 1998	?	
Internalizing problems	No	Brodersen, 2005 (boys); Coyne, 2011 (girls); Lohaus, 2005 (girls); Özmert, 2002		
	Positive	Brodersen, 2005 (girls); Coyne, 2011 (boys); Holtz, 2011; Lohaus, 2005 (boys); Parke, 2013; Robinson, 2011	+	
	No	Colwell, 2000; Colwell, 2003; Dominick, 1984 (girls); Fling, 1992; Hargborg, 1995; Harman, 2005; Holder, 2009; Martins, 2012; Mesch, 2006; Robinson, 2003; Subervi-Velez, 1990; Webb, 2013; Wiggins, 1987		
Self-esteem	Positive	Stroman, 1986	?	--
	Negative	Dominick, 1984 (boys); Durkin, 2002; Goldfield, 2007; Jackson, 2010; Leatherdale, 2011; McClure, 2010; Nihill, 2013; Racine, 2011; Russ, 2009; Tin, 2012; Tucker, 1987		

Eating disorder symptoms	No	Borzekowski, 2000; Botta, 2000; Calado, 2010 (girls) ; Fouts, 2002; Harrison, 2000b (boys); Jackson, 2010; Moriarty, 2008 (boys); Neumark-Sztainer, 2004 (girls); Nihill, 2013; Racine, 2011 ; Schooler, 2011; Tiggemann, 1996; Webb, 2013 (boys)	?
Inattention and hyperactivity problems	Positive	Calado, 2010 (boys) ; Eyal, 2013; Forrest, 2008; Goldfield, 2007; Harrison, 2000a; Harrison, 2000b (girls); Holder, 2009; Iannotti, 2009 ; Moriarty, 2008 (girls); Neumark-Sztainer, 2004 (boys); Robinson, 2003; Webb, 2013 (girls)	
Well-being and quality of life	No	Ferguson, 2011	
	Positive	Brodersen, 2005 ; Chan, 2006; Landhuis, 2007; Levine, 2000; Lingineni, 2012 ; McWilliams, 2013; Özmert, 2002; Parkes, 2013; Swing, 2010; van Egmond-Fröhlich, 2012	+ ++
	Negative	Borras, 2011; Brodersen, 2005 (boys) ; Gross, 2002; Willoughby, 2008 Brodersen, 2005 (girls) ; Chen, 2005 ; Chen, 2008; Dalton, 2011; Dumith, 2010 ; Gopinath, 2012 ; Holder, 2009; Iannotti, 2009 ; Lacy, 2012 ; Page, 2010 ; Ussher, 2007	- --

Summary coding: +, positive association; -, negative association; ?, indeterminate association

Bold printed: high quality studies (7-9 points)

Quality coding: ++/- -/00, four or more high quality studies support the association

Eleven of the included studies adjusted their results for physical activity, and found SB to be associated with poorer mental health, at least with one of the assessed indicators. These findings provide evidence that SB should be considered as an independent risk factor for mental health. In a number of studies especially high users of screen-based devices are at risk of reporting poor mental health. In contrast, considering especially depressive symptoms, a u-shaped association was demonstrated (Do et al., 2013; Durkin and Barber, 2002; Kim, 2012), i.e. adolescents using the internet and video games in a moderate way showed the lowest prevalence of depressive symptoms. Even though there were only few studies analyzing curvilinear trends, using the internet and having a computer might be important for social integration and appreciation for adolescents in modern societies. The longitudinal and intervention studies included in this review give first hints about the direction of causality, i.e. it is assumed that SB effects mental health negatively. Nevertheless, this is not a conclusive statement, since in one study, for example, screen time was predicted by depressive symptoms half a year ago (Schmitz et al., 2002). Youths with poor mental health may prefer to spend their time sedentary.

There is little research on explaining mechanisms and mediating variables for the relationship between SB and mental health. Several explanations have been assumed. Time engaging in SB might replace time spent otherwise with physical activity which is associated with better mental health (Ahn and Fedewa, 2011; Biddle and Asare, 2011). In several studies, a negative relationship between physical activity and SB was reported (Pearson et al., 2014). However, as outlined above, in a few studies that controlled for physical activity, screen time was still found to be an independent risk factor for poor mental health.

Furthermore, more time spent with watching TV or using the internet is supposed to lead to social withdrawal, social isolation, and hence to internalizing problems and less well-being (Kraut et al., 1998). Another possible explanation why SB might be negatively associated with indicators of mental health might be specific for screen-based SB. TV and especially the internet provide diverse opportunities to compare themselves not only in terms of physical

appearance but also with respect to other skills, experiences or talents. Discrepancies between these publicized ideals and the self could cause social pressure and mental health problems. With regard to hyperactivity/inattention problems two other important mediating variables should be emphasized. On the one hand, high levels of SB are related to higher body mass index and unfavorable body composition (Tremblay et al., 2011) which themselves are associated with a higher rate of attention-deficit/hyperactivity disorder and less quality of life (Erhart et al., 2012; Ottova et al., 2012). On the other hand, it was hypothesized that if children get used to the rapid changes of impressions in TV programs they will have difficulties paying attention to the slower “real life” e.g. in school (Christakis et al., 2004). All of these mechanisms are supposed to play a role in the complex and diverse associations between SB and different aspects of mental health, and need to be further investigated in future research.

Strengths and limitations

There are several strengths of this review. To ensure methodological quality, this systematic review was in compliance with the PRISMA Statement (Liberati et al., 2009). Following a comprehensive search strategy of different electronic databases and using a-priori defined inclusion and exclusion criteria enabled a systematic review of existing literature. In contrast to other reviews examining the relationship between SB and mental health in youth, a wide range of age and indicators of mental health, different types of SB and both genders were included. Only articles published in peer-reviewed journal were used for this review. On the one hand, this approach ensured a minimum of quality of the primary studies. On the other hand, it is an important limitation to this review, since publication biases could not be identified. The majority of included primary studies used reliable and validated measurement tools to assess indicators of mental health. However, only few studies measured SB objectively through accelerometer use. In many cases a single screen-based indicator for SB was used, which has been shown to be no suitable marker for overall SB. (Biddle et al., 2009) In addition, it is not possible to attribute the negative mental health effects of screen time

conclusively to the fact that it is spent sedentary, since negative media influences could be present as well. Another major problem was the study design. Eighty percent of the 91 included studies were cross-sectional. Thus, it is not possible to draw conclusions about causality. Finally, due to the high heterogeneity of primary studies, a meta-analytical approach was not applicable.

Implications and future research

Adolescents' lifestyle in modern societies is often characterized by spending large parts of the day sedentary. The adverse physical health effects of high levels of SB in childhood and adolescence are well established (Carson and Janssen, 2011b; Ekelund et al., 2012; Mitchell et al., 2012; Tremblay et al., 2011). As demonstrated in the presented systematic review, associations between SB and indicators of mental health are not that conclusive and need to be further investigated. In a lot of studies SB is insufficiently operationalized through a single screen-based indicator. Thus, using objective measures or at least a wide range of SB should be a major goal in future research to promote the understanding of the role of SB concerning mental health. However, the adverse relationships with self-esteem, hyperactivity/inattention problems and internalizing problems might be important for primary prevention and public health, since the diversity of opportunities for spending leisure-time sedentary considerably increased during the past decades. The majority of youth has free access to TVs and computers, or even has own smartphones. These electronic devices can serve important needs of children and adolescents (Lohaus et al., 2005), and seem to play a central role in their everyday life. Thus, an important goal of primary prevention should be to identify these needs and try to meet them in a more physically active way. While the enhancement of physical activity is a major goal of a number of prevention programs, a contemporary approach should emphasize the reduction of time spent sedentary as well, since both approaches seems to be necessary for the health of children and adolescents in modern societies. On the other hand, it is likely that children and adolescents with poor mental health prefers to spend their time with screen-based SB. Providing online mental

health information and access to internet-based self-help interventions might be another important avenue in primary prevention to capture this at risk population. Beforehand, it could be that hyperactivity/inattention problems or low levels of well-being are risk factors for developing a more sedentary lifestyle in youth. Thus, the possibility of using such mental health problems as a screening measure to provide tailored health behavior interventions regarding physical activity and sedentary behavior to those adolescents might be of public health relevance.

There are four major issues for future research. First, more studies measuring SB objectively or at least a wide range including also non-screen-based activities are needed to attribute adverse mental health effects clearly to the time spent sitting and not merely to media influences, and make a distinction between both mechanisms, respectively. Second, more longitudinal studies are necessary to clarify the direction of causality. Third, studies examining mechanisms linking SB to adverse mental health outcomes and investigating whether etiologies differ for different indicators of mental health are preferable. Fourth, due to the inconsistent results for most mental health indicators the investigation of moderating variables would be reasonable.

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Supplementary materials

Additional file 1: Search strategy for each online database

MEDLINE via Ovid

1. Sedentary lifestyle/
2. (sedentary or sedentariness or sitting).tw.
3. video games/ or television/ or internet/ or computers/
4. ((tv or television or screen) adj (time or watch\$3)).tw.
5. ((computer or internet or web) adj (time or us\$3)).tw.
6. (video gam\$3 or electronic gam\$3 or computer gam\$3).tw.
7. (screen-based entertainment or screen based entertainment).tw.
8. or/1-7
9. mental health/ or mental disorders/
10. (mental health or mental disease? or mental disorder? or mental illness).tw.
11. self efficacy/ or self concept/
12. (self-efficacy or self efficacy or self esteem or self-esteem or self concept or self-concept).tw.
13. personal satisfaction/ or "quality of life"/ or stress, psychological/
14. (life satisfaction or quality of life or stress or well-being or wellbeing).tw.
15. anxiety/ or anxiety disorders/
16. (anxiety).tw.
17. Dysthymic disorder/ or depression/ or depressive disorder/ or affective symptoms/ or mood disorders/
18. (depress\$3 or dysthymi? or emotional problem?).tw.
19. Attention deficit disorder with hyperactivity/
20. (attention deficit disorder? OR attention deficit hyperactivity disorder? or AD?D).tw.
21. Anorexia nervosa/ or eating disorders/ or anorexia/ or bulimia/ or bulimia nervosa/
22. (eating disorder? OR anorexia OR bulimia).tw.
23. Or/9-22
24. adolescent/ or child/
25. (youth? OR adolescen\$2 OR young people OR young person? OR teen\$ or child\$ or juvenile).tw.
26. 24 or 25
27. 8 and 23 and 26
28. Limit 27 to human

Searched through 01.11.2013, 3141 journal articles found

EMBASE via Ovid

1. Sedentary lifestyle/ or sitting/
2. (sedentary or sedentariness or sitting).tw.
3. Computer/ or internet/ or television/ or television viewing/
4. ((tv or television or screen) adj (time or watch\$3)).tw.
5. ((computer or internet or web) adj (time or us\$3)).tw.
6. (video gam\$3 or electronic gam\$3 or computer gam\$3).tw.
7. (screen-based entertainment or screen based entertainment).tw.
8. Or/1-7
9. Mental health/ or mental disease/
10. (mental health or mental disease? or mental disorder? or mental illness).tw.
11. Self concept/ or self esteem/
12. (self-efficacy or self efficacy or self esteem or self-esteem or self-concept or self concept).tw.
13. "quality of life"/ or emotional stress/ or stress/ or mental stress/ or wellbeing/ or life satisfaction/
14. (life satisfaction or quality of life or stress or well-being or wellbeing).tw.
15. anxiety disorder/ or anxiety/
16. (anxiety).tw.
17. Dysthymia/ or depression/ or major depression/ or emotional disorder/
18. (depress\$3 or dysthymi? or emotional problem?).tw.
19. Attention deficit disorder/
20. (attention deficit disorder? OR attention deficit hyperactivity disorder? or AD?D).tw.
21. Eating disorder/ or anorexia nervosa/ or anorexia/ or bulimia/
22. (eating disorder? OR anorexia OR bulimia).tw.
23. Or/9-22
24. Adolescence/ or child/ or childhood/ or juvenile/ or adolescent/
25. (youth? OR adolescen\$2 OR young people OR young person? OR teen\$ or child\$ or juvenile).tw.
26. 24 or 25
27. 8 and 23 and 26
28. Limit 27 to human

Searched through 01.11.2013, 2459 journal articles found

PsycINFO/ PsycARTICLES via EBSCO

1. (TI (sedentary or sedentariness or sitting)) or (AB (sedentary or sedentariness or sitting))
2. DE (television or television viewing)
3. (TI ((tv or television or screen) and (time or watch*))) or (AB ((tv or television or screen) and (time or watch*)))
4. DE (computer usage or computer games or internet usage)
5. (TI ((computer or internet or web) and (time or us*))) or (AB ((computer or internet or web) and (time or us*)))
6. (TI (video gam* or electronic gam* or computer gam*)) or (AB (video gam* or electronic gam* or computer gam*))
7. S1 OR S2 OR S3 OR S4 OR S5 or S6
8. DE (mental health or mental disorders)
9. (TI (mental health or mental disorder? or mental illness or mental disease?)) or (AB (mental health or mental disorder? or mental illness or mental disease?))
10. DE (self esteem or self concept or self efficacy)
11. (TI (self-esteem or self esteem or self-efficacy or self efficacy or self-concept or self concept)) or (AB (self-esteem or self esteem or self-efficacy or self efficacy or self-concept or self concept))
12. DE (life satisfaction or quality of life or stress or well being)
13. (TI (life satisfaction or quality of life or stress or well-being or wellbeing)) or (AB (life satisfaction or quality of life or stress or well-being or wellbeing))
14. DE (major depression or depression or dysthymic disorder or affective disorders)
15. (TI (depress* or dysthymi? or emotional problem?)) or (AB (depress* or dysthymi? or emotional problem?))
16. DE (anxiety or anxiety disorders)
17. (TI (anxiety)) or (AB (anxiety))
18. DE (attention deficit disorder or attention deficit disorder with hyperactivity)
19. (TI (attention deficit disorder? or attention deficit hyperactivity disorder? or ad?d)) or (AB (attention deficit disorder? or attention deficit hyperactivity disorder? or ad?d))
20. DE (eating disorders or bulimia or anorexia nervosa)
21. (TI (eating disorder? or anorexia or bulimia)) or (AB (eating disorder? or anorexia or bulimia))
22. S8 or S9 or S10 or S11 or S12 OR S13 OR S14 OR S15 OR S16 OR S17 or S18 OR S19 OR S20 OR S21
23. (TI (juvenile or adolescent? or adolescence or child* or youth? or young people or young person? or teen*)) or (AB (juvenile or adolescent? or adolescence or child* or youth? or young people or young person? or teen*))
24. S7 AND S22 AND S23

Searched through 01.11.2013

psycINFO: 1771 journal articles found

psycARTICLES: 58 journal articles found

SPORTDiscus

1. (DE "SEDENTARY behavior") OR (DE "SEDENTARY lifestyles")
2. (TI (sedentary or sedentariness or sitting)) or (AB (sedentary or sedentariness or sitting))
3. (TI ((tv or television or screen) and (time or watch*))) or (AB ((tv or television or screen) and (time or watch*)))
4. (DE "Internet")
5. (TI ((computer or internet or web) and (time or us*))) or (AB ((computer or internet or web) and (time or us*)))
6. (DE "COMPUTER games") or (DE "INTERNET games") or (DE "VIDEO gamers") OR (DE "ELECTRONIC games")
7. (TI (video gam* or electronic gam* or computer gam*)) or (AB (video gam* or electronic gam* or computer gam*))
8. S1 OR S2 OR S3 OR S4 OR S5 OR S6 or S7
9. (DE "MENTAL health") OR (DE "MENTAL illness")
10. (TI (mental health or mental disorder? or mental illness or mental disease?)) or (AB (mental health or mental disorder? or mental illness or mental disease?))
11. (DE "SELF-esteem") OR (DE "SELF-efficacy")
12. (TI (self-esteem or self esteem or self-efficacy or self efficacy or self-concept or self concept)) or (AB (self-esteem or self esteem or self-efficacy or self efficacy or self-concept or self concept))
13. (DE "QUALITY of life") or (DE "WELL-being") OR (DE "STRESS (Psychology)")
14. (TI (life satisfaction or quality of life or stress or well-being or wellbeing)) or (AB (life satisfaction or quality of life or stress or well-being or wellbeing))
15. DE "ANXIETY"
16. (TI (anxiety)) or (AB (anxiety))
17. (DE "MENTAL depression") OR (DE "AFFECTIVE disorders")
18. (TI (depress* or dysthymi? or emotional problem?)) or (AB (depress* or dysthymi? or emotional problem?))
19. (DE "ATTENTION-deficit hyperactivity disorder")
20. (TI (attention deficit disorder? or attention deficit hyperactivity disorder? or ad?d)) or (AB (attention deficit disorder? or attention deficit hyperactivity disorder? or ad?d))
21. (DE "EATING disorders") OR (DE "ANOREXIA nervosa") OR (DE "BULIMIA")
22. (TI (eating disorder? or anorexia or bulimia)) or (AB (eating disorder? or anorexia or bulimia))
23. S9 or S10 or S11 S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 or S21 or S22
24. (DE "TEENAGERS") OR (DE "YOUTH") OR (DE "CHILDREN")
25. (TI (juvenile or adolescent? or adolescence or child* or youth? or young people or young person? or teen*)) or (AB (juvenile or adolescent? or adolescence or child* or youth? or young people or young person? or teen*))
26. S24 OR S25
27. S8 AND S23 AND S26

Searched through 01.11.2013, 205 journal articles found

CINAHL via EBSCO

1. (MH "Life Style, Sedentary") or (MH "Sitting")
2. (TI (sedentary or sedentariness or sitting)) or (AB (sedentary or sedentariness or sitting))
3. (MH "Television")
4. (TI ((tv or television or screen) and (time or watch*))) or (AB ((tv or television or screen) and (time or watch*)))
5. (MH "Internet")
6. (TI ((computer or internet or web) and (time or us*))) or (AB ((computer or internet or web) and (time or us*)))
7. (MH "Video Games")
8. (TI (video gam* or electronic gam* or computer gam*)) or (AB (video gam* or electronic gam* or computer gam*))
9. S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8
10. (MH "Mental Health") or (MH "Mental Disorders")
11. (TI (mental health or mental disorder? or mental illness or mental disease?)) or (AB (mental health or mental disorder? or mental illness or mental disease?))
12. (MH "Self Concept") or (MH "Self-Efficacy") or (MH "Self-Esteem (Iowa NOC)")
13. (TI (self-esteem or self esteem or self-efficacy or self efficacy or self-concept or self concept)) or (AB (self-esteem or self esteem or self-efficacy or self efficacy or self-concept or self concept))
14. (MH "Personal Satisfaction") OR (MH "Quality of Life (Iowa NOC)") or (MH "Psychological Well-Being") or (MH "Well-Being (Iowa NOC)") or (MH "Psychological Well-Being (Iowa NOC) (Non-Cinahl)") or (MH "Stress, psychological")
15. (TI (life satisfaction or quality of life or stress or well-being or wellbeing)) or (AB (life satisfaction or quality of life or stress or well-being or wellbeing))
16. (MH "Anxiety ") or (MH "Anxiety Disorders")
17. (TI (anxiety)) or (AB (anxiety))
18. (MH "Depression ") or (MH "Dysthymic Disorder")
19. (TI (depress* or dysthymi? or emotional problem?)) or (AB (depress* or dysthymi? or emotional problem?))
20. (MH "Attention Deficit Hyperactivity Disorder")
21. (TI (attention deficit disorder? or attention deficit hyperactivity disorder? or ad?d)) or (AB (attention deficit disorder? or attention deficit hyperactivity disorder? or ad?d))
22. (MH "Eating Disorders") OR (MH "Bulimia Nervosa") or (MH "Anorexia") OR (MH "Anorexia Nervosa") OR (MH "Bulimia")
23. (TI (eating disorder? or anorexia or bulimia)) or (AB (eating disorder? or anorexia or bulimia))
24. S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23
25. (MH "Adolescence") or (MH "Child")
26. (TI (juvenile or adolescent? or adolescence or child* or youth? or young people or young person? or teen*)) or (AB (juvenile or adolescent? or adolescence or child* or youth? or young people or young person? or teen*))
27. S25 OR S26
28. S9 AND S24 AND S27

Searched through 01.11.2013, 1104 journal articles found

Additional file 2: Risk of bias assessment: Newcastle-Ottawa Scale adapted for cross-sectional studies

Selection (maximum 4 points)

1. Representativeness of the sample

1 point	<ul style="list-style-type: none"> Truly representative sample of the target population (random sampling) Somewhat representative of the target population (non-random sampling)
0 point	<ul style="list-style-type: none"> Selected group of users No description of sampling strategy

2. Sample size

1 point	<ul style="list-style-type: none"> Justified and satisfactory
0 point	<ul style="list-style-type: none"> Not justified

3. Non-respondents

1 point	<ul style="list-style-type: none"> Comparability between responders and non-responders characteristics is established Satisfactory response rate
0 point	<ul style="list-style-type: none"> Comparability between respondents and non-respondents is unsatisfactory The response rate is unsatisfactory No description of response rate or characteristics of the responders and the non-responders

4. Ascertainment of the "risk factor": sedentary behavior

1 point	<ul style="list-style-type: none"> Validated measurement tool Non-validated measurement tool, but the tool is described and appropriate
0 point	<ul style="list-style-type: none"> No description of the measurement tool

Comparability (maximum 2 points)

5. Confounding factors are controlled

2 points	<ul style="list-style-type: none"> The study controls for physical activity and additional factors
1 point	<ul style="list-style-type: none"> The study controls for any additional factor
0 point	<ul style="list-style-type: none"> Confounding factors are not controlled

Outcome (maximum 3 points)

6. Assessment of the "outcome": indicator of mental health

1 point	<ul style="list-style-type: none"> Validated measurement tool Non-validated measurement tool, but the tool is described and appropriate
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0 point	<ul style="list-style-type: none"> No description of the measurement tool
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7. Statistical test

1 point	<ul style="list-style-type: none"> The statistical test used to analyze the data is described and appropriate
0 point	<ul style="list-style-type: none"> The statistical test used to analyze the data is not described or not appropriate

8. Reporting

1 point	<ul style="list-style-type: none"> Main findings are described and estimates of the random variability in the data for the main outcomes are provided
0 point	<ul style="list-style-type: none"> No description of the main results or no information about random variability

**3.3 Manuskript 2 – bildschirmgebundenes versus bildschirmungebundenes
Sedentary Behavior und Indikatoren des psychischen Wohlbefindens im
Jugendalter**

Sedentary behavior, depressed affect, and indicators of mental well-being in adolescence: Does the screen only matter for girls?

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Abstract

The study investigated the effects of sedentary behavior (SB) on mental well-being and examined differences between screen-based (sSB) and non-screen-based sedentary behaviors (nSB) separately by gender. In a total sample of 1 296 students (609 girls) aged 12-17 ($m=13.7$, $SD=0.67$), SB, depressed affect, self-esteem, physical self-concept, general self-efficacy and physical activity were assessed through self-administered questionnaires. Among girls, lower scores in self-esteem, physical self-concept as well as general self-efficacy were associated with higher sSB but not nSB. Among boys higher levels of sSB related to higher self-esteem, nSB but not sSB predicted higher scores in depressed affect, and there was a u-shaped association between sSB and general self-efficacy. Results replicate the inverse association between SB and mental well-being, and suggest a distinction between nSB and sSB especially among girls. Additional studies will be necessary to replicate, and further examine mediating mechanisms.

Key words: sedentary behavior; screen time; mental well-being; adolescence

Background

Sedentary behavior (SB) comprises activities requiring low levels of energy expenditure (Pate, O'Neill, & Lobelo, 2008). In addition to traditional SB such as reading or sitting while talking to others, modern societies offer a multitude of screen-based sedentary leisure-time pursuits such as using Social Media, playing video or computer games or watching television (TV). Children and adolescents in western societies spend about 4-8 hours a day being sedentary (Pate, Mitchell, Byun, & Dowda, 2011).

A growing body of research examining negative impacts of SB on youth's physical health found increased SB to be linked to an unfavorable body composition, lower cardiovascular fitness and a higher cardio-metabolic health risk (Tremblay et al., 2011). Negative effects of a sedentary lifestyle on indicators of adolescents' mental health seem to be evident as well. Regarding the nine included primary studies in a brief review by Biddle and Asare (2011), the authors found consistent negative associations between SB and mental health outcomes, mainly psychological well-being, depressive symptoms and physical self-concept. Consistent with these findings a review by Tremblay and colleagues (2011) outlined the negative impacts of SB on self-esteem as well.

These findings could be of major importance, since adolescence is a critical period for the development of mental health problems (Kessler et al., 2005). There are some studies investigating long-term effects of SB on mental health providing first hints for causality. For instance, using a 7 year follow-up Primack et al. (Primack, Swanier, Georgiopoulos, Land, & Fine, 2009) found media exposure in adolescence to be

associated with increased depressive symptoms in young adulthood. Other longitudinal studies have revealed similar small but consistent negative impacts of SB on health-related quality of life (Gopinath, Hardy, Baur, Burlutsky, & Mitchell, 2012), self-esteem (Martins & Harrison, 2012) and psychological adjustment (Parkes, Sweeting, Wight, & Henderson, 2013). Furthermore, reducing the amount of time spent with sedentary activities is assumed to be a promising strategy for prevention of mental health problems (Goldfield et al., 2007).

A number of studies dealing with SB used the time spent watching TV as a proxy of overall SB. But in consideration of a decline in TV viewing and an increase of non-gaming computer use during the past decade (Bucksch, Inchley, Hamrik, Finne, & Kolip, 2014), TV use seems not to be a suitable indicator for overall sitting time. In addition, asking only for TV use or even total screen time might underestimate adolescents' overall SB, since adolescents participate in a variety of non-screen-based SB as well (Bauer, Friend, Graham, & Neumark-Sztainer, 2012; Zabinski, Norman, Sallis, Calfas, & Patrick, 2007). Biddle and colleagues (Biddle, Gorely, & Marshall, 2009) found a negative association between the amounts of time spent watching TV, and doing sedentary hobbies, homework or sitting and talking. To date, it is unclear whether there are differential effects of screen-based sedentary behavior (sSB) and non-screen-based sedentary behavior (nSB) on adolescents' mental health. Thus, it is not possible to attribute the negative mental health effects of screen time to the fact that it is spent sedentary or to negative media influences.

A significant proportion of studies investigating associations between SB and adolescents' mental health did not take into account moderate to vigorous physical

activity (MVPA). For more than a decade both behaviors have been conceptualized as distinct health risk factors (Pate et al., 2008). Previous research demonstrated that there are a lot of adolescents being both highly active and highly sedentary (Wong & Leatherdale, 2009). Both MVPA and SB relate to mental health in children and adolescents but in opposite directions (Biddle & Asare, 2011). However, SB has emerged as an independent health risk factor, since studies that controlled for MVPA still found associations between SB and indicators of mental health which are indeed smaller but still significant (Finne, Bucksch, Lampert, & Kolip, 2014; Iannotti et al., 2009).

Furthermore, it seems to be important to differentiate between boys and girls, since they differ not merely with respect to the time spent sedentary (Pate et al., 2011) but also concerning the prevalence of internalizing mental health problems: depressive disorders, low self-esteem and anxiety problems affect girls more often than boys (Patton & Viner, 2007; Durkin & Barber, 2002).

This exploratory study has two aims: 1) to examine differences in the relationship between mental health outcomes, and sSB and nSB, respectively, and 2) to investigate effects of SB on depressed affect and different indicators of mental well-being taking MVPA into account. These objectives will be pursued separately for boys and girls.

Methods

Study design and participants

Baseline data from the cluster-randomized controlled trial of the “läuft.” program

(Suchert et al., 2013) were used for the current cross-sectional study. The “läuft.” program is a school-based intervention aimed at fostering a physically active lifestyle in adolescence. The whole study has been approved by the ethics committee of the German Psychological Society as well as the Ministry of Education and Science of Schleswig-Holstein. To recruit the study sample 134 secondary schools in the federal state of Schleswig-Holstein in Germany were invited to participate with their 8th grade classes. Finally, 29 schools (21.6%) with 61 classes and 1,489 students decided to take part in the study. Data collection took place from January to March 2014. Data of 1 296 students were eligible.

Measures

An anonymous, self-administered questionnaire was employed to obtain data about students' socio-demographic characteristics, the amount of time spent with different SB and MVPA as well as indicators of their mental well-being. Additionally, body weight and height were measured.

Sedentary behavior. An adapted version of the survey method by Zabinski and colleagues (2007) was used to assess leisure time SB. Students were asked how much time they spent on the most recent school day and the most recent Sunday with the following activities: watching TV/DVDs, playing video/computer games (except active electronic gaming), other leisure-time pursuits on the computer/mobile phone, passive transport, doing homework, reading, listening to music, creative hobbies, and talking to others. Average numbers of minutes spending with each activity were summed up to a total amount of SB. The time spent with sSB was determined by summing up the first three activities. The average minutes spending

with the other sedentary activities were summed up to total time spent with nSB. Each of these scores was cut down to a maximum of 24 hours. Due to their skewed distribution these three summed scores (total SB, sSB and nSB) were each grouped into quartiles based on the gender-specific samples.

Depressed affect. The subscale “depressed affect” of the German version of the Center for Epidemiological Studies Depression Scale for Children was used to assess an important domain of depressive symptoms (CES-DC; Barkmann, Erhart, & Schulte-Markwort, 2008; Faulstich, Carey, Ruggiero, Enyart, & Gresham, 1986). Students were asked how often they have felt different depressive symptoms during the last week (4-point rating-scale 0-3). The subscale “depressed affect” showed a good split-half reliability of 0.77 and the whole scale was highly correlated with other tests for depression (Barkmann et al., 2008). The internal consistency for the present sample was $\alpha = 0.89$.

General self-efficacy. Five items of the general self-efficacy scale of Schwarzer and Jerusalem (1999) were administered asking students to evaluate how well they are described by different statements (4-point rating-scale 0-3). In different German samples excellent internal consistencies from 0.80 to 0.90 and satisfactory criterion validity have been demonstrated (Schwarzer & Jerusalem, 1999). For the sample analyzed here, Cronbach’s alpha was $\alpha = 0.68$.

Self-esteem. Three items of the KINDL-R were administered (Erhart, Ellert, Kurth, & Ravens-Sieberer, 2009). Students were asked to indicate how they felt about themselves during the last week (5-point rating-scale 0-4). In a representative sub-

sample of the German KiGGS survey the scale showed good convergent validity and an internal consistency of 0.70 (Bullinger, Brutt, Erhart, & Ravens-Sieberer, 2008).

For the present sample, the internal consistency was $\alpha = 0.75$.

Self-concept of physical attractiveness. To measure self-concept of physical attractiveness, 5 items of the physical self-concept scales by Stiller et al. (Stiller, Würth, & Alfermann, 2004) were used. Students were asked to indicate the extent to which they agree with different statements (4-point rating scale 0-3). In diverse samples good retest reliabilities after 5 weeks and one year ranging between 0.68 and 0.90 were demonstrated. The internal consistencies for the subscale “physical attractiveness” ranged between 0.82 and 0.86. Satisfactory validity was proven using specific self-worth scales. For the analyzed sample in this study, Cronbach’s alpha was $\alpha = 0.90$.

For each scale an average score was determined with higher scores indicating higher depressed affect, self-esteem, general self-efficacy and a more positive physical self-concept, respectively.

Covariates. Students’ age was assessed as well as their education (type of school they attend). There are three common types of school in the federal state of Schleswig-Holstein (excluding schools for disabled students) into which students are grouped after grade 4: “Gymnasium” (college-preparatory school), “Gemeinschaftsschule” (comprehensive school) and “Regionalschule” (general/secondary school). Allocation to one of these school types is mainly determined by school achievement and the socio-economic status of students’

parents (Lange et al., 2007; Richter & Leppin, 2007). In the present study two values were assigned: 0 for “Gemeinschaftsschule” and “Regionalschule” which tend to recruit students from low- to middle-class families and 1 for “Gymnasium” which serves mainly students from middle- and upper-class families. To gain information about students’ physical activity the two-item screening instrument by Prochaska and colleagues which has been proven to be a reliable and valid measure for MVPA in adolescence (Prochaska, Sallis, & Long, 2001) was administered. Students were asked on how many days of the last week as well as of a usual week they have been physically active for at least 60 minutes per day. They should only relate to physical activity that made them breathe faster and increased their heart rate. Both items were combined to an average score. Standing height was determined using a portable stadiometer (Seca 213, Basel, Switzerland) and body weight using an electronic scale (Omron BF-511, Omron Healthcare, Mannheim, Germany). Students’ Body Mass Index (BMI) was calculated ($\text{weight}/\text{height}^2$) and converted into age- and gender-specific percentiles on the basis of a representative German sample (Kromeyer-Hauschild et al., 2001) using Coles LMS-method (Cole, 1990). According to BMI percentiles, students were classified into three weight status groups: underweight ($\leq 10^{\text{th}}$ percentile), normal weight (between 10^{th} and 90^{th} percentile), and overweight ($\geq 90^{\text{th}}$ percentile).

Statistical analysis

All statistical analyses were realized using Stata version 13.1 (Stata Corp, College Station, Texas, USA). To test for gender differences in study variables, Fisher’s exact test or t-test were applied. In consideration of very small intraclass correlations (ranging between 0 and 0.1), multiple linear regression analyses were conducted to

investigate the associations between SB scores and indicators of mental well-being. Depressed affect was log-transformed before being entered into regression analyses due to its highly skewed distribution. Each mental health indicator was regressed on each SB score separately for boys and girls including age, weight status, and education in a first step, and as additional predictor MVPA in a second step. SB scores were entered 1) using a dummy variable to test each quartile against the first quartile, and 2) using quartiles as continuous variable to test for p for trend. Additionally, potential non-linear trends were identified by visual inspection and adding a quadratic term to the regression analyses. Cases with missing data on one of the study variables or covariates were excluded (10.0-13.1%).

Results

Description of the study sample

The study sample comprised 609 girls (47.0%) and 687 boys (53.0%) aged between 12 and 17 years with a mean age of 13.7 years (SD=0.67 years). Detailed information about distributions in the study variables as well as gender specific information are reported in Table 1. Boys were slightly older than girls, were more physically active and pursued nSB to a lesser extent than girls. In addition, boys showed consistently better mental well-being across all indicators. There were no significant gender differences according to education, weight status, total SB and sSB.

Table 1: Socio-demographic characteristics and study variables for the total sample as well as girls and boys separately (läuft Study, Germany, 2014)

	Total sample (N=1,296)	Girls (N=609)	Boys (N=687)
Age (SD)	13.7 (0.67)	13.7 (0.64)	13.8 (0.70)
		p=0.001	
Education (type of school)			
“Regionalschule”/ “Gemeinschaftsschule”	58.0%	55.3%	60.4%
“Gymnasium”	42.0%	44.7%	39.6%
		p=0.342	
Days per week of at least 60 minutes of MVPA (SD)	4.0 (1.69)	3.9 (1.62)	4.2 (1.75)
		p=0.003	
Weight status			
Underweight	4.2%	4.8%	3.7%
Normal weight	77.1%	76.5%	77.7%
Overweight	18.7%	18.7%	18.6%
		p=0.641	
Total SB (SD) in hours/day	7.1 (5.24)	7.1 (5.58)	7.0 (4.93)
		p=0.598	
Screen-based SB (SD) in hours/day	4.1 (3.99)	3.8 (4.36)	4.3 (3.64)
		p=0.069	
Non-screen-based SB (SD) in hours/day	3.1 (2.86)	3.5 (3.08)	2.8 (2.60)
		p<0.001	
Depressed affect ¹ (SD)	0.4 (0.51)	0.5 (0.61)	0.2 (0.34)
		p<0.001	
Self-esteem ² (SD)	2.6 (0.88)	2.3 (0.88)	2.8 (0.80)
		p<0.001	
Self-concept for physical attractiveness ¹ (SD)	2.0 (0.72)	1.8 (0.76)	2.2 (0.62)
		p<0.001	
General self-efficacy ¹ (SD)	2.0 (0.43)	1.9 (0.40)	2.0 (0.44)
		p<0.001	

MVPA – moderate to vigorous physical activity

SB – sedentary behavior

SD – standard deviation

¹ range: 0-3, higher scores indicating higher depressed affect/self-concept for physical attractiveness/general self-efficacy

² range: 0-4, higher scores indicating higher self-esteem

SB in the study sample

Students in the study sample spent about 7 hours a day sedentary. Both boys and girls spent more time in sSB than in nSB. There was a considerable greater discrepancy among boys (4.3 hrs sSB/ 2.8 hrs nSB) than among girls (3.8 hrs sSB/ 3.5 hrs nSB). Furthermore, the latter spent significantly more time with nSB and less with sSB than boys.

SB and mental health indicators in girls

As presented in Table 2, total SB was associated with higher depressed affect ($\beta=0.163$, $p<0.001$), less self-esteem ($\beta=-0.104$, $p=0.015$), less physical attractiveness ($\beta=-0.146$, $p<0.001$) and less general self-efficacy ($\beta=-0.091$, $p=0.033$). In detail, only girls with the highest level of SB showed significant poorer mental health: girls in the highest quartile of total SB reported significantly higher levels of depressed affect ($\beta=0.192$, $p<0.001$), less self-esteem ($\beta=-0.118$, $p=0.024$), less physical attractiveness ($\beta=-0.163$, $p=0.001$) and less general self-efficacy ($\beta=-0.105$, $p=0.042$) compared to girls in the lowest quartile.

Different effects of sSB and nSB were found for almost all mental health indicators. Regarding self-esteem, physical attractiveness and general self-efficacy, higher sSB but not nSB was a significant predictor of lower scores (Table 2). Girls in the highest quartile of sSB showed an average reduction of 0.26 points in self-esteem ($p=0.016$), 0.29 points in physical attractiveness ($p = 0.001$) and 0.14 points in general self-efficacy ($p = 0.004$) compared to girls in the lowest quartile. Predictive margins for each quartile are shown in Figure 1. With regard to depressed affect, sSB ($\beta=0.094$, $p=0.032$) as well as nSB ($\beta=0.118$, $p=0.005$) were linked to significantly higher

scores. A J-shaped association of total SB as well as sSB with depressed affect was identified by adding squared terms in regression analyses. For total SB the adjusted regression coefficient for the simple score was $\beta=0.165$ ($p<0.001$) and for the squared score $\gamma=0.143$ ($p=0.007$), for sSB $\beta=0.097$ ($p=0.027$) and $\gamma=0.133$ ($p=0.011$). Comparing both models, with and without MVPA as additional predictor, coefficients of SB scores adjusted for MVPA are in most cases slightly smaller than in the first model without MVPA. Results of the first model can be taken from Appendix A.

SB and mental health indicators in boys

Among boys, higher levels of depressed affect were associated with nSB ($\beta=0.084$, $p=0.033$) but not with total SB ($\beta=0.052$, $p=0.192$) or sSB ($\beta=-0.024$, $p=0.552$). All results for boys are presented in Table 3. Reported self-esteem was unaffected by total SB ($\beta=0.035$, $p=0.410$) as well as nSB ($\beta=-0.036$, $p=0.390$). In contrast to girls, there was a significant positive association between sSB and self-esteem among boys ($\beta=0.105$, $p=0.014$). Self-esteem of boys in the highest quartile of sSB was 0.19 points ($p=0.043$) higher than among boys in the lowest quartile. Physical attractiveness was found to be completely unaffected by all kinds of SB (Table 3).

Figure 2 shows the predictive margins for all indicators of mental well-being as function of the sSB and nSB quartiles. With regard to general self-efficacy, a u-shaped association with total SB and sSB was obvious, since only boys in the third quartile showed decreased scores for general self-efficacy compared to boys in the lowest quartile with $\beta=-0.101$ ($p = 0.033$) and $\beta=-0.111$ ($p = 0.018$), respectively.

Table 2: Results of multiple linear regression analyses adjusted for age, weight status, education and moderate to vigorous physical activity in girls

	Depressed affect		Self-esteem		Self-concept for physical attractiveness		General self-efficacy	
	β (95%-CI)	p-value	β (95%-CI)	p-value	β (95%-CI)	p-value	β (95%-CI)	p-value
Total SB	0.163 (0.078 to 0.247)	<0.001	-0.104 (-0.188 to -0.020)	0.015	-0.146 (-0.225 to -0.066)	<0.001	-0.091 (-0.175 to -0.007)	0.033
Screen-based SB	0.094 (0.008 to 0.180)	0.032	-0.090 (-0.174 to -0.005)	0.039	-0.125 (-0.206 to -0.044)	0.003	-0.134 (-0.218 to -0.049)	0.002
Non-screen-based SB	0.118 (0.035 to 0.200)	0.005	-0.069 (-0.152 to 0.013)	0.098	-0.077 (-0.156 to 0.002)	0.056	-0.010 (-0.092 to 0.073)	0.816

β – standardized regression coefficient

95%-CI – 95% Confidence-Interval

SB – sedentary behavior

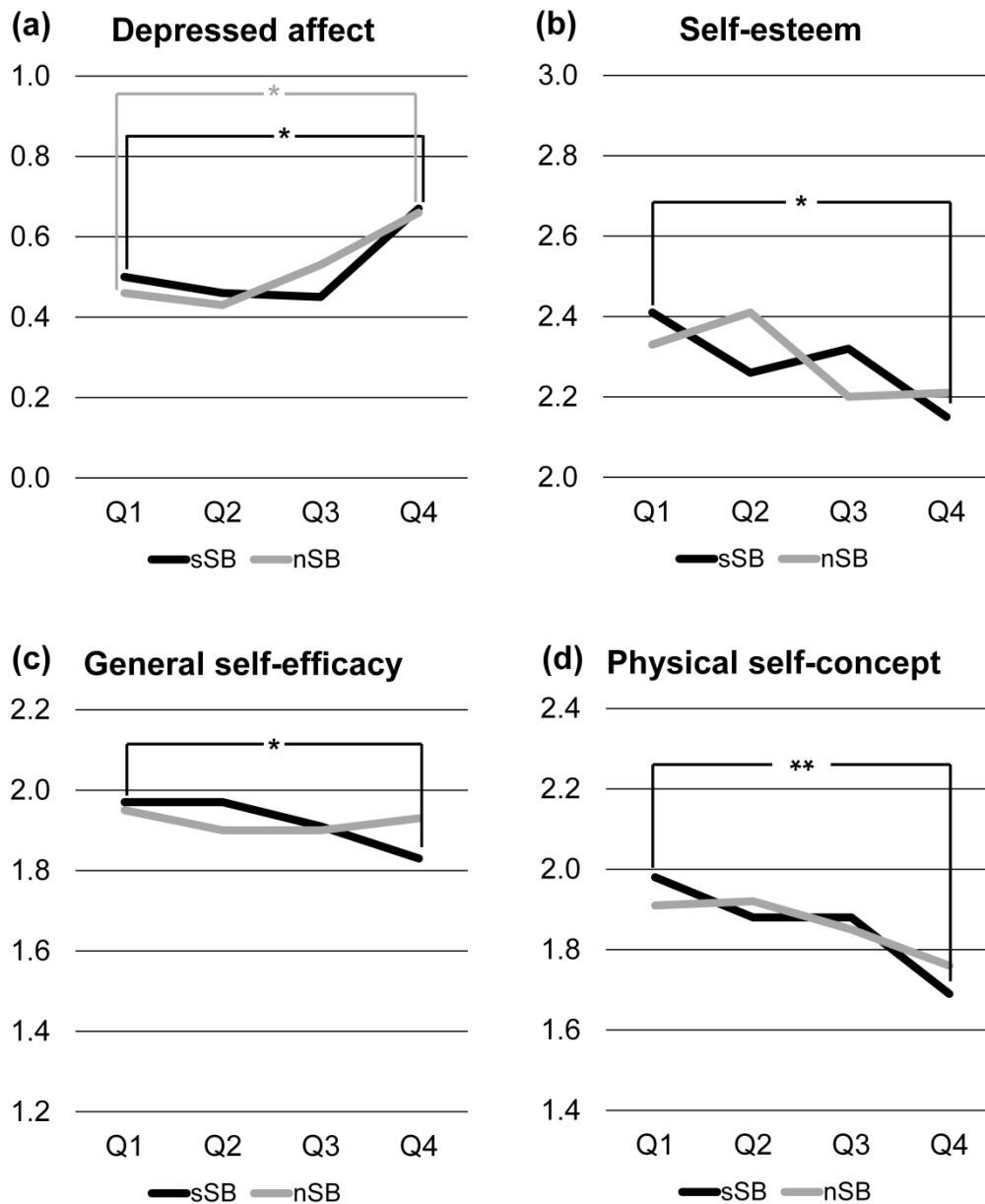


Figure 1 (a-d): Predictive margins for each indicator of mental well-being as a function of screen-based (sSB) and non-screen-based (nSB) sedentary behavior quartiles in girls. Quartiles 2 to 4 (Q2 to Q4) are tested for significance against the first quartile (Q1).

* $p < 0.05$, ** $p < 0.001$

Testing for this apparent u-shaped trend by adding the quadratic term of SB scores, revealed a significant quadratic term only for sSB but not for total SB. Adjusted coefficients for the simple sSB score was $\beta = -0.031$ ($p = 0.416$) and for the quadratic

term $\gamma=0.094$ ($p=0.039$). Removing MVPA as additional predictor produced only marginal differences between the coefficients of SB scores. These results are presented in Appendix A.

Discussion

The current study intended to examine differences in the relationship between indicators of mental well-being and sSB and nSB, respectively, taking MVPA into account. SB was an independent predictor for all mental health indicators among girls but not among boys. Girls with the highest amount of SB were at a significantly higher risk for poorer mental health than girls in the lowest quartile. Accordingly, findings of the present study suggest differences between sSB and nSB especially for girls. Lower scores in self-esteem, physical self-concept as well as general self-efficacy were associated with higher sSB but not with nSB in girls. For depressed affect there was no difference between sSB and nSB. Both predicted higher scores of depressed affect.

Adjusting the regression coefficients for MVPA slightly attenuated the examined effects or did not change them in most cases. This fact might be due to the small effect sizes in general, and our measure of physical activity. In a meta-analysis by Marshall and colleagues (Marshall, Biddle, Gorely, Cameron, & Murdey, 2004) the authors reported that only vigorous physical activity was associated with sSB but not a combined score including also moderate physical activity. Differences in regression coefficients were especially obvious in the highest quartile of SB. It might be possible that a displacement of MVPA by SB is only relevant in the highest quartile.

Table 3: Results of multiple linear regression analyses adjusted for age, weight status, education and moderate to vigorous physical activity in boys

	Depressed affect		Self-esteem		Self-concept for physical attractiveness		General self-efficacy	
	β (95%-CI)	p-value	β (95%-CI)	p-value	β (95%-CI)	p-value	β (95%-CI)	p-value
Total SB	0.052 (-0.026 to 0.131)	0.192	0.035 (-0.048 to 0.117)	0.410	-0.004 (-0.082 to 0.074)	0.992	-0.031 (-0.105 to 0.043)	0.417
Screen-based SB	-0.024 (-0.104 to 0.055)	0.552	0.105 (0.021 to 0.188)	0.014	0.036 (-0.042 to 0.115)	0.365	-0.034 (-0.109 to 0.041)	0.380
Non-screen-based SB	0.084 (0.007 to 0.161)	0.033	-0.036 (-0.117 to 0.046)	0.390	-0.060 (-0.136 to 0.016)	0.123	-0.021 (-0.093 to 0.052)	0.578

β – standardized regression coefficient

95%-CI – 95% Confidence-Interval

SB – sedentary behavior

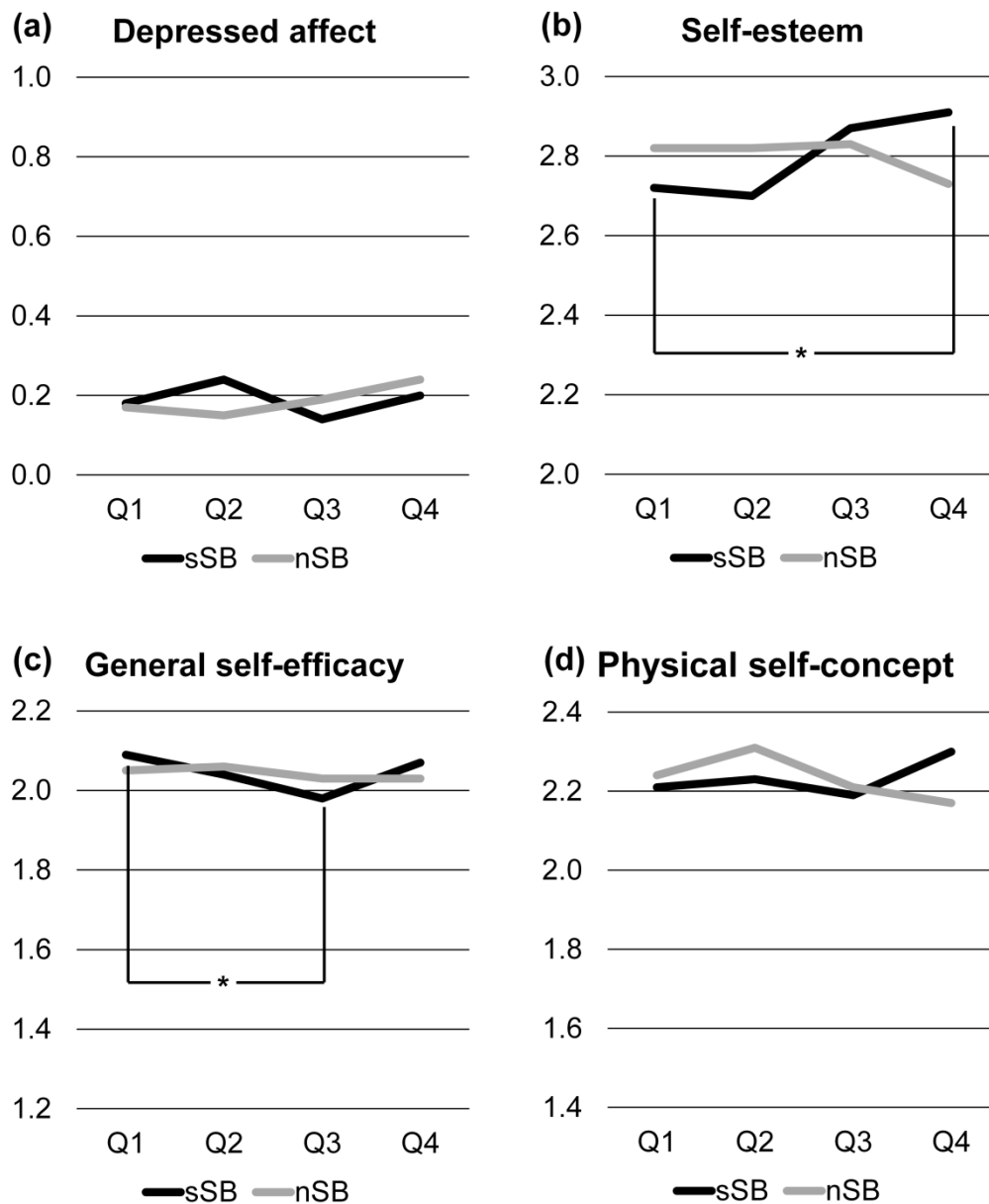


Figure 2 (a-d): Predictive margins for each indicator of mental well-being as a function of screen-based (sSB) and non-screen-based (nSB) sedentary behavior quartiles in boys. Quartiles 2 to 4 (Q2 to Q4) are tested for significance against the first quartile (Q1).

* $p < 0.05$

Nevertheless, the identified effects of SB on adolescents' mental health confirm findings of previous studies focusing mainly on sSB (Costigan, Barnett, Plotnikoff, & Lubans, 2013; Eyal & Te'eni-Harari, 2013; Russ, Larson, Franke, & Halfon, 2009).

While in the present study adverse effects of SB are mainly observed in girls, most of the studies mentioned above did not distinguish between genders. In line with our findings, a study by Finne et al. (Finne et al., 2014) revealed significant effects of SB on self-esteem and emotional well-being almost exclusively for girls. One important reason might be the better mental health status concerning internalizing problems in boys (Durkin & Barber, 2002; Patton & Viner, 2007) and marginal variance in the assessed mental health indicators of the male study participants. Besides, a few studies identified positive associations between sSB and quality of social relationships (Iannotti et al., 2009) that seems to be especially prevalent in boys (Finne et al., 2014). Thus, social aspects of sSB might be of special importance among boys and could have positive influences on other indicators of mental well-being.

With regard to body dissatisfaction the different association patterns between boys and girls could be due to the greater sociocultural importance of ideal body shapes and physical attractiveness for women and girls in western societies (McKinley, 1999). In the media, mainly screen-based, unrealistic female body ideals are ubiquitous and negatively associated with the physical self-concept for attractiveness especially among girls (Eyal & Te'eni-Harari, 2013; Groesz, Levine, & Murnen, 2002). The presence and conveyance of thin unrealistic body ideals are supposed to be the most critical difference between sSB and nSB with regard to mental health problems among girls. In a study by Eyal and Te'eni-Harari (2013) the authors demonstrated that the identification with favored characters in the media who are mostly thin and beautiful leads to enlarged discrepancies between the own and the ideal body shape that are assumed to relate to greater body dissatisfaction. Body dissatisfaction is

closely related to lower self-esteem (Finne et al., 2014; Furnham, Badmin, & Sneade, 2002). Furthermore, the use of Social Media like Facebook or Twitter is of high prevalence among adolescents in modern societies, and is connected to several harassments for mental health (O'Keeffe & Clarke-Pearson, 2011). TV, the internet and especially Social Media provide diverse opportunities to compare themselves not only in terms of physical appearance but also with respect to other experiences and talents. Discrepancies between these publicized ideals and the self could cause social pressure and mental health problems. Considering popular characters in the media, potential future research might explore the extent to which these characters and the amount of media consumption are part of rehearsal for adult roles and therefore are important in the adolescents' development.

While in a review by Tremblay et al. (Tremblay et al., 2011) the authors outlined a consistent negative association between screen time and self-esteem in children and adolescents, in the present study a positive association between sSB and self-esteem among boys was identified, which might be supported by a study by Durkin and Barber (2002). They demonstrated that low as well as high levels of computer game play among adolescents affected self-esteem positively compared to not playing computer games at all. The positive effects could be due to the requirement and improvement of cognitive skills related to playing computer games as well as the achievement of increasing challenges within the game (Subrahmanyam, Greenfield, Kraut, & Gross, 2001). Concerning the findings that boys spend much more time with playing computer and video games than girls (Durkin & Barber, 2002), this might be a possible explanation.

In this light, the apparent u-shaped association between sSB and general self-efficacy among boys could be understood, since the mastery of increasing levels of difficulty within computer and video games are assumed to be a source of increasing self-efficacy (Bandura, 1997). However, own performance accomplishments are only one source of self-efficacy. This could also be a reason why high levels of sSB among girls were associated with low general self-efficacy. On the other hand, adolescents with higher general self-efficacy are supposed to engage in and maintain health behaviors more frequently (Bandura, 1997), which might also include reduced SB.

A different association pattern was observed for depressive symptoms. Total SB as well as sSB and nSB were significantly related to depressed affect in girls. These findings imply a more general and possibly physiological mechanism involved in the relationship between high levels of sitting and depressed affect compared to a rather specific screen-dependent or content-related influence concerning the indicators of mental well-being presented above. On the other hand, it is reasonable that depressed adolescent girls are more likely to be sedentary in general. In addition, a J-shaped association between total SB as well as sSB and depressive symptoms was found. Among adolescents in modern societies it might be necessary to use the media to some extent in order to comply with social norms. In boys, the more time they spent with nSB the higher they scored in depressed affect. A study by Sund et al. (2011) showed high levels of sedentary behavior to be predictive for boys' depressive symptoms one year later. Authors included sSB as well as nSB out of school.

There are several strengths of the present study: This is one of the first studies investigating differential effects of nSB and sSB on mental well-being in adolescence. Therefore, it adds an important point to the current research, since most studies have focused on screen time. Significant confounders, such as weight status, gender and MVPA, were taken into account. On the one hand, the large study sample enhances the external validity of the presented results. On the other hand, the insecure cultural transferability limits the external validity. Another important limitation of the current study is the measurement method, since SB was only assessed subjectively through self-report which could have caused: a) misclassifications, since not all screen time is spent sedentary, and b) time in which students engaged in two sedentary leisure-time pursuits simultaneously could have been reported twice leading to an overestimation of SB. Nevertheless, in a systematic review by Pate et al. (2011) the authors indicated no significant difference between self-reported and by accelerometry objectively measured SB in adolescents. Moreover, using self-reported information enabled an exact distinction between sSB and nSB. Second, since data are cross-sectional, conclusions about causality of the presented results cannot be drawn.

In line with other studies, the presented findings suggest negative associations between SB and mental well-being independent of MVPA, at least in adolescent girls. In light of the huge amounts of time adolescents spend sedentary, these findings are considerable for public health and require further research. Particularly in adolescent girls, nSB and sSB should be considered separately in future studies. Additional studies will be necessary to replicate and further examine the current findings. A next step should be a detailed investigation of different kinds and contents of sSB and

nSB in association with mental health problems, for instance variations regarding patterns and total amounts of SB between week and weekend days. Especially the examination of possible mediating variables and mechanisms will be of major importance.

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Appendix A

Table A.1: Results of multiple linear regression analyses adjusted for age, weight status and education in girls

	Depressed affect		Self-esteem		Self-concept for physical attractiveness		General self-efficacy	
	β (95%-CI)	p-value	β (95%-CI)	p-value	β (95%-CI)	p-value	β (95%-CI)	p-value
Total SB	0.175 (0.091 to 0.258)	<0.001	-0.122 (-0.206 to -0.039)	0.004	-0.159 (-0.238 to -0.080)	<0.001	-0.123 (-0.207 to -0.038)	0.004
Screen-based SB	0.108 (0.022 to 0.193)	0.013	-0.108 (-0.193 to -0.023)	0.012	-0.139 (-0.220 to -0.058)	0.001	-0.162 (-0.247 to -0.077)	<0.001
Non-screen-based SB	0.122 (0.040 to 0.205)	0.004	-0.077 (-0.159 to 0.006)	0.069	-0.083 (-0.162 to -0.004)	0.039	-0.024 (-0.107 to 0.060)	0.582

β – standardized regression coefficient

95%-CI – 95% Confidence-Interval

SB – sedentary behavior

Table A.2: Results of multiple linear regression analyses adjusted for age, weight status and education in boys

	Depressed affect		Self-esteem		Self-concept for physical attractiveness		General self-efficacy	
	β (95%-CI)	p-value	β (95%-CI)	p-value	β (95%-CI)	p-value	β (95%-CI)	p-value
Total SB	0.058 (-0.020 to 0.135)	0.147	0.021 (-0.061 to 0.103)	0.641	-0.017 (-0.094 to 0.061)	0.671	-0.060 (-0.135 to 0.015)	0.119
Screen-based SB	-0.016 (-0.094 to 0.063)	0.695	0.084 (0.002 to 0.167)	0.044	0.017 (-0.061 to 0.094)	0.671	-0.072 (-0.148 to 0.004)	0.062
Non-screen-based SB	0.080 (0.004 to 0.157)	0.040	-0.036 (-0.117 to 0.045)	0.382	-0.059 (-0.135 to 0.017)	0.131	-0.014 (-0.089 to 0.060)	0.705

β – standardized regression coefficient

95%-CI – 95% Confidence-Interval

SB – sedentary behavior

3.4 Manuskript 3 – Studienprotokoll einer Evaluationsstudie zur Wirksamkeit der schulbasierten Intervention „läuft.“

STUDY PROTOCOL

Open Access

“läuft.” - a school-based multi-component program to establish a physically active lifestyle in adolescence: study protocol for a cluster-randomized controlled trial

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Abstract

Background: Physical activity during childhood and adolescence is associated with substantial health benefits and tracks into adulthood. Nevertheless, only 22.7% of German adolescents are sufficiently physically active. Thus, the promotion of an active lifestyle in youth is an essential issue of public health.

This study will evaluate the implementation and efficacy of the “läuft.” program to enhance physical activity in adolescence. “läuft.” is a multicomponent school-based program developed on the basis of effective strategies for health interventions and behavioral change.

Methods/design: The “läuft.” physical activity program targets four different levels. (a) Each student receives a pedometer and documents his/her steps over 12 weeks using an interactive user account on the “läuft.” homepage. (b) For classes there will be different competitions, with achieving the most steps in selected weeks, the highest increases of steps and developing the most inventive ideas to promote physical activity in school. Besides, the intervention includes four educational lessons. (c) The headmasters and teaching staff of the participating schools will get information material with suggestions and encouragement to enhance physical activity in school. Participating teachers will be invited to an introductory seminar. (d) Parents will be provided with informational material about the program and will be invited to a parent-teacher conference about the benefits of being physically active and how they can support their children in engaging in a physically active lifestyle. To evaluate the efficacy of the “läuft.” physical activity program, a two-arm cluster randomized controlled trial will be conducted in three waves: (1) baseline assessment, January/February 2014, (2) post assessment, June/July 2014 and (3) 12-month follow-up assessment, June/July 2015. Data collection will include physical and medical testing, self-administered questionnaires, group discussions and document analyses.

Discussion: “läuft.” aims at fostering a physically active lifestyle in adolescence while a considerable decline of physical activity is present. Physical activity programs based in the school setting and following a multicomponent approach have been proven to be most successful. Furthermore, the use of pedometers is promising to enhance physical activity during the entire day and targets a wide range of adolescents regarding fitness and weight.

Trial registration: Current Controlled Trials ISRCTN49482118.

Keywords: Physical activity, Cluster-randomized trial, Adolescents, School-based intervention, Pedometer

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Background

There is extensive literature emphasizing physical activity as an important and modifiable factor influencing physical and mental health: being physically active on a regular basis is associated with substantial health benefits [1-4], including primary and secondary prevention of chronic diseases, a reduced risk of premature death and better mental health.

Physical activity in childhood and adolescence prevents a widespread variety of chronic diseases, including hypertension, obesity and depression [5,6]. An active lifestyle early in life is not just important for health outcomes in adolescence but may also be a significant factor for the level of activity in adulthood and health-related physical fitness [7-10]. Global recommendations on physical activity suggest that children and adolescents should take part in physical activity of moderate to vigorous intensity for at least 60 minutes per day to maintain health [11]. In consideration of epidemiological data, only 17.3% of female and 28.2% of male adolescents in Germany aged 11 to 17 years meet these recommendations [12]. Moreover, physical activity declines in older adolescents compared to children and younger adolescents [13]. Nader *et al.* reported a decline of moderate-to-vigorous physical activity from 180 minutes per day at 9 years to only 42 minutes per day at 15 years [14]. Hence, the promotion of an active lifestyle and physical fitness in early adolescence is an issue worthy of intervention development.

Considering the access to a large adolescent population, interventions based in the school setting are supposed to be the method of choice for increasing physical activity in youth [15]. Meta-analyses and reviews indicated positive impacts of school-based interventions for promoting physical activity on health-related indicators, namely an increase of rate and duration of in-school physical activity as well as aerobic fitness and a decrease of blood cholesterol and of physical inactivity [15-18]. Notably, multicomponent interventions involving peers, parents and communities were assumed to be highly effective [18]. However, despite these encouraging outcomes, almost no improvements in out-of-school physical activity has emerged from studies to date, and increases in activity level were rather short-term [17,18]. Therefore, school-based programs which aim to enhance physical activity and fitness in adolescents should also focus on changing the everyday routine to increase out-of-school physical activity and on establishing an active lifestyle in the long term.

There are several options for interventions to induce effects on physical activity throughout the entire day. One promising approach could be the use of pedometers which has already been shown to be effective in increasing physical activity among adolescents [19,20],

not just in-school but also during out-of-school [21,22]. These findings are supplemented by studies emphasizing self-monitoring and goal-setting as one of the most effective intervention strategies to promote physical activity [23,24]. Both strategies can be easily and effectively combined with pedometer use [20]. The "läuft." program integrates these strategies that have been proven to be successful in the promotion of physical activity into a multicomponent approach [15,18] that is school-based [15,17,18] and includes social support from peers and parents [25], goal-setting and self-monitoring through pedometer use [23,24].

Objectives and hypotheses

The aim of the study is to evaluate the implementation and effectiveness of the "läuft." physical activity program among adolescents in grade 8. Therefore, a two-arm three-wave cluster randomized controlled trial will be conducted. Expected effects on primary outcomes of the "läuft." program in the intervention compared to the control group are defined as:

1. an increase in physical activity in general and in different contexts measured by questionnaires;
2. a decrease of sedentary behavior measured by questionnaires; and
3. an increase in cardiovascular fitness measured by the 20-meter shuttle run test.

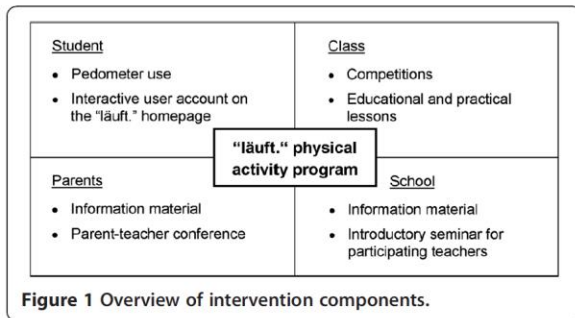
In addition to primary outcomes, the following secondary outcomes will be included in the evaluation study of the "läuft." physical activity program: body composition (that is, Body Mass Index (BMI), percentage of body fat mass and waist circumference), cardiovascular risk factors (that is, blood pressure, heart rate after stress as well as resting and recovery heart rate), mental health (that is, general self-efficacy, psychological well-being, self-esteem and depression), enjoyment of physical activity and sedentary behaviors, physical self-concept (that is, general physical capacity and physical attractiveness), self-efficacy towards physical activity, intention for physical activity and physical well-being.

Methods/design

Intervention

"läuft." was designed by an interdisciplinary team of sport medicine specialists, sport scientists, teachers, nutritional scientists and psychologists.

The intervention operates at four levels: individual, class, school and parents. The intervention period is 12 weeks. An overview of all components of the intervention is shown in Figure 1.



Class

The core components of the intervention are class competitions. On the one hand, each individual student in the class receives a pedometer and records the daily amount of steps over a period of 12 weeks. Steps are summed up to a class mean, documented on a class poster and reported to the project staff in three selected weeks. On the other hand, each class collects creative and inventive ideas on how to increase physical activity in everyday school life and keeps records of these ideas on the "läuft." homepage (www.laeuft.info). In addition, the classes take part in four educational lessons: (1) introduction to the "läuft." program, distribution of pedometers and informational material for students and their parents, (2) introduction to the creativity contest, (3) physical activity that combines running/walking with exercises at environmental facilities (for example, a bench, stairs or a jungle gym), and (4) reflection of strategies to take more steps in everyday life and setting of physical activity goals for the time period after the project. Besides, additional modules are offered that can be flexibly conducted during the program. The modules deal with topics such as the reflection of student's physical activity, motives for being physically active or possible barriers to physical activity and how to handle them. Each lesson takes 45 minutes and will be conducted by teachers of the participating classes. After the end of the competition period, classes with the highest means of steps per week, with the largest increases and with the most inventive and creative class projects are awarded.

Individual

By using a pedometer, each student can evaluate his or her daily physical activity objectively and compare it to the class mean and common recommendations. Additionally, students can document their steps as well as their experiences during the program using a private and interactive user account on the "läuft." homepage. Based on students' entries, statistics (for example, mean of the week or day of best performance), a diagram to follow daily step totals over time and feedback will be delivered.

Furthermore, the homepage provides opportunities to share experiences with other participating students and compete on step totals. The homepage is optimized for online use with smartphones.

School

The headmaster and entire teaching staff of each participating school will receive information material, including background and description of the program, activity-promoting teaching methods, suggestions on how to improve the school environment to stimulate physical activity, and related links leading to further information. All participating teachers will be offered an introductory seminar to learn more about the concept and components of the "läuft." program.

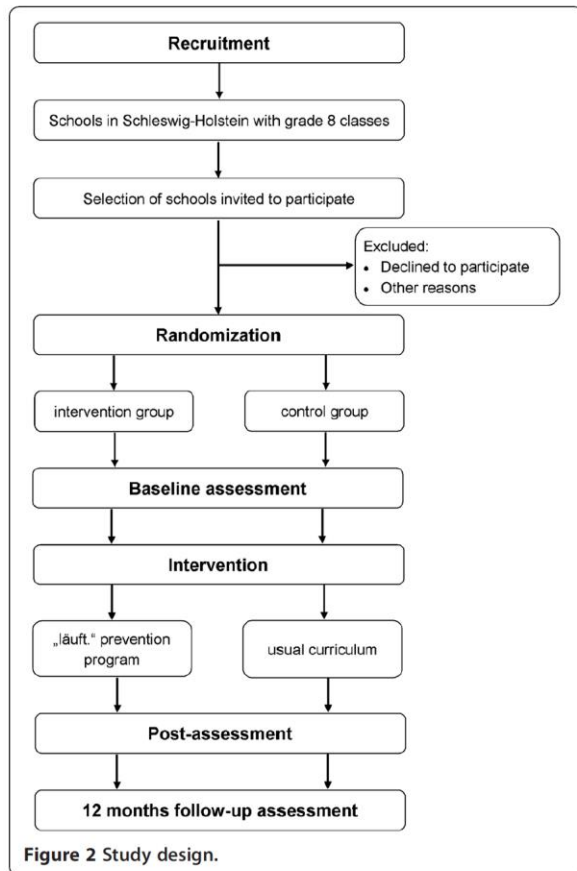
Parents

A parent-teacher conference will take place at the class level to emphasize the importance of physical activity throughout the entire life and give parents ideas of how to support their children in establishing a physically active lifestyle. In addition, parents will receive information material about the program and the assessments. To take parents with a foreign background into account, materials will also be available in Turkish and Russian as the most frequently spoken foreign languages in Germany.

Study design

The effectiveness of the "läuft." physical activity program will be tested in a two-arm three-wave cluster randomized controlled trial. Data of the different waves are hypothesized to be clustered at the individual, class and school level. Schools are the units of randomization and will be randomly allocated to the intervention and control group. In intervention schools the "läuft." physical activity program will be implemented, while schools of the control group run through the usual curriculum and will receive no further intervention. In both groups, fitness, medical and questionnaire data will be collected for three times: "baseline" (immediately before the intervention), "post" (immediately after the intervention) and "follow-up" (12 months after the end of the intervention) assessment. In addition, after the intervention, qualitative analyses will be conducted in classes of the intervention group to gain insight into interactive processes within the classes and to reconstruct subjective experiences and interpretations of activating-strategies.

Process evaluation of the planned trial will be realized through questionnaires and interviews during and after the study, respectively. The study design is presented in Figure 2.



Sample size calculation

There are specific constraints for analysis of cluster randomized trials [26] since the responses of individuals within a cluster tend to be more similar than those of individuals of different clusters. This clustering effect can be defined as $1 + (m-1)\rho$, where m is the average number of subjects per cluster and ρ the intraclass correlation coefficient (ICC) [27]. The ICC for physical fitness and adiposity was taken from another cluster randomized controlled trial, the Kindersportstudie (KISS) [28,29] and estimated with approximately 0.05 (ρ). Assuming an equal average cluster size of 20 pupils with parental consent ($m = 20$), a clustering effect of 1.95 was determined. Without taking into account the clustering of the data, assuming a small to medium effect size of the intervention (Cohen's $d = 0.30$) on physical activity as one primary and the most important outcome being still detectable at follow-up, applying a significance level of $\alpha = 0.05$ and power = 0.80, it can be estimated that $N = 350$ pupils are required to detect a difference between two independent sample means [30,31]. Taking the cluster effect into account, a required sample size of $N = 683$ students and 34 classes was determined. A computerized sample

size calculator for cluster randomized trials was used to confirm this estimation [32].

Based on earlier experiences [33,34], a drop-out rate of 25% over the study was hypothesized. Hence, a total sample size of 911 pupils and 46 classes will be recruited for baseline to detect possible differences between the groups at follow-up. In order to recruit the estimated sample size of 46 classes while assuming a participation rate of 20% and an average of at least two participating classes per school, about 100 schools will be invited to participate.

Procedure and participants

The study has been approved by the ethics committee of the German Psychological Society as well as the Ministry of Education and Science of Schleswig-Holstein. It targets 8th grade classes with students aged 12 up to 15 years in secondary schools in the federal state of Schleswig-Holstein in Germany. Schools will be selected from a complete list of all secondary schools in Schleswig-Holstein obtained from the Ministry of Education. All types of schools will be included, except schools for disabled students. In order to recruit a study sample of 46 classes, about 100 schools will be invited to participate. An invitation letter and information sheets about the aims, methods and requirements of the study will be sent to the head of each school. Copies of the letters of approval by the Ministry of Education and the ethics committee will be attached. Schools agreeing to participate must send back their written consent indicating the acceptance of study characteristics (including randomization), number of grade 8 classes eligible for the study, names of the class teachers, and number of students per class. All students of participating classes will be included in the study. Schools not agreeing to participate are requested to explain their denial. In order to conduct non-responder analysis, all invited schools will be asked to provide some basic data about type and size of school, number of grade 8 classes, gym and sports equipment, sports facilities on the school ground and offered sports events, projects and courses. Participating schools will be stratified (type of school and number of grade 8 classes) and randomly allocated to the intervention and the control groups. Furthermore, parents will receive information sheets about the study and will be asked for informed consent to the storage and use of assessed data of their children. Teachers will register all names of students with no permission in a list which they keep throughout the entire trial. Students with refusals will take part in the assessment but their data will not be registered.

Randomization

To avoid interference between the intervention and the control groups, stratified randomization will be carried

out on the school level (according to the type of school and number of grade 8 classes). Expecting a higher drop-out of schools in the intervention group, randomization follows a 3:2 ratio, that is, each school will have a 3:2 chance of being assigned to the an intervention group. Randomization will be performed with a computer program.

Data collection

From October 2013 to January 2014 the recruitment and randomization of schools will take place. In the intervention as well as in the control group, baseline data will be obtained in January and February 2014. The intervention program is scheduled for the period of March to May 2014. During this time the control group runs the usual curriculum. After 12 weeks, in the period of June to July 2014, post assessment data will be obtained. The follow-up assessment is planned for June and July 2015.

Pilot study

The program has been tested, evaluated and adapted during a pilot study. From April to June 2013 a pilot study with a shorter intervention period (eight weeks) was conducted, including two schools with four classes and 89 students (41 female students; $M_{age} = 13$ years, $SD = 0.50$ years). To evaluate and improve the "läuft." physical activity program, different qualitative and quantitative methods were employed: participant observation of the educational lessons, questionnaires for students and teachers to evaluate these lessons, and the assessment as well as interviews with students and teachers about the entire intervention. Based on the insights gained with respect to feasibility, comprehensibility and acceptance from the obtained data and experiences, the program was modified. The intervention was followed by one assessment in order to evaluate the feasibility of physical and medical testing as well as the comprehensibility of the questionnaire. The assessment was adapted in accordance with the experiences and results.

Measures

The outcomes will be measured anonymously with self-administered questionnaires, physical testing and medical testing on the individual level as well as qualitative methods on the individual and the class level. An overview of all outcomes that will be assessed is presented in Table 1.

To permit a linking of individual information on subsequent assessments while assuring anonymity, each assessment-booklet will be labeled with a seven-digit individual code generated by the student [54].

Table 1 Overview of measures

Measurement methodology	Outcome	
Medical testing	Body weight and height (BMI percentiles)	
	Body composition (fat mass)	
	Waist circumference [35]	
	Blood pressure	
	Resting heart rate	
	Heart rate after stress	
	Recovery heart rate	
	Physical testing	Cardiovascular fitness [36]
		Questionnaire
	Age	
	Gender	
	Migration background	
	Socio-economic status [37]	
<i>Lifestyle Behavior</i>		
Physical activity* [38-40]		
Sedentary behavior [40]		
Use of tobacco [41]		
Use of alcohol [42,43]		
Food pattern [44]		
<i>Psychological constructs</i>		
General self-efficacy [45]		
Self-efficacy towards physical exercise [46]		
Self-concept for general physical capacity and physical attractiveness [47,48]		
Enjoyment of physical activity [49]		
Enjoyment of sedentary behavior [49]		
Sensation seeking [50]		
Physical well-being [51]		
Psychological well-being [51]		
Depression [52]		
Intention for physical activity [53]		
<i>Social factors</i>		
Parental support for physical activity [25]		
Friends physical activity*		
Normative expectations*		
Environmental situation to be physical active*		
Qualitative methods	Activating-strategies (group discussion, document analysis)	
	Interactive processes (group discussion)	

*self-constructed items.

Medical testing

Standing height will be determined using a portable stadiometer (Seca 213, Basel, Switzerland) and body weight as well as body composition (fat mass) using

bioelectrical impedance analysis (Omron BF-511, Omron Healthcare, Mannheim, Germany). Students' BMI will be calculated and converted into age- and gender-specific percentiles using the Coles LMS-method [55] on the basis of a representative German sample [56]. For further analysis, the standard deviation scores will be determined. Blood pressure and resting heart rate will be measured with an automated oscillometric device (M5-Professional, Omron Healthcare, Mannheim, Germany). A flexible tape will be used to determine waist circumference at the medial axillary line half-way between the lowest rib and the iliac crest [35]. For measuring heart rate after stress as well as recovery heart rate after three minutes, respectively, pulse watches with chest belts will be used (Polar FT1, Polar Electro GmbH, Büttelborn, Germany). The entire medical testing will be conducted under a physician's supervision.

Physical testing

For measuring cardiovascular fitness, the 20-meter shuttle run test will be conducted [36]. In this progressive running test, the students have to run between two lines for a distance of 20 meters. The required running pace of an initial 8.0 km/h increases continuously by 0.5 km/h each minute. Students have to cross the opposite line in a given time interval indicated by prerecorded audio signals. The test stops when the student fails to reach the line by the sound for the second time. To determine aerobic capacity, the number of one-minute stages will be counted with a precision of 0.5 stages. The 20-meter shuttle run test allows a validated estimation of maximal oxygen uptake as an indicator of cardiovascular fitness [57,58].

Questionnaire

Data about socio-demographic characteristics, lifestyle behaviors well as psychological and social variables will be collected by self-administered questionnaires. The items and scales used are based on published and validated questionnaires and the international literature. The entire questionnaire was tested for feasibility and comprehensibility during the pilot study with 89 students. Based on the experiences in the pilot study regarding comprehensibility and acceptance of items and conducted item analyses, the questionnaire has been revised and shortened. Considering item analyses, items have been excluded if (a) item difficulty was smaller than 20% and larger than 80%, respectively, (b) item-rest correlation was smaller than .40 and (c) their exclusion either led to higher internal consistencies or did not substantially decrease internal consistency of the particular scale.

Table 2 summarizes item characteristics and internal consistencies of the scales that have been modified based on the results of the pilot study and that will be

employed in the planned study. Furthermore, for self-constructed items and scales seven-day retest-reliabilities were determined on a subsample of 38 students.

Socio-demographic characteristics Socio-demographic characteristics like school type, age, gender and migration background will be assessed as well as the socio-economic status asking for the parents' highest educational attainment [37].

Lifestyle behavior Adapted items of the MoMo-activity-questionnaire [38] will be used to assess physical activity in different contexts (school, sports clubs and leisure time) and in different dimensions (duration, frequency and intensity) as well as the mode of commuting to school. These questions provide information about physical activity during a regular week. Besides, students in the pilot study were asked with which activities they choose to spend their recess time in school. The three activities that were named the most (sitting or standing while talking to others, walking through the school or schoolyard, and sports such as football or basketball) will be included in the final questionnaire. Students will be asked how often they engaged in these activities during the recess times of the last week. Overall moderate to vigorous physical activity will be determined by a reliable and validated two-item screening measure [39]. The survey method for leisure time sedentary behavior was modified from Zabinski and colleagues [40]. Students will be asked how much time they spent on the most recent school day and the most recent Sunday with different sedentary behaviors. Different physical activities were added to the list providing insights into the distribution of sedentary and active leisure time during a specific day. The list of activities is based on the original questionnaire, categories for physical activity (active transport, household activities, physical activity in sports clubs, in school and in leisure time), and extended by answers of students in the pilot study. Lifetime smoking and current smoking [41] as well as lifetime alcohol use, current alcohol use and frequency/number of previous binge drinking [42,43] will be assessed. Finally, students will be asked how often they consume different foodstuff in a usual week, namely, fresh fruits and vegetables, sweets or chocolate, soft drinks, fast food and water [44] (retest-reliability (r) ranged from 0.39 to 0.63).

Psychological variables Items of published and validated scales selected with respect to item analysis during the pilot study will be used for the assessment of general self-efficacy [45], self-efficacy towards physical activity [46], physical self-concept for general physical capacity and physical attractiveness [47,48], enjoyment of physical activity PACES (Physical Activity Enjoyment Scale) [49],

Table 2 Item characteristics and internal consistencies of modified scales in their final version

Scales	Number of Items	Pilot study (N = 89)		
		Cronbach's α	Item-rest correlation	Item difficulty (in%)
General self-efficacy	5	.83	.58 to .66	60.8 to 68.2
Self-concept: general physical capacity	5	.92	.78 to .83	50.6 to 70.5
Self-concept: physical attractiveness	5	.84	.58 to .71	57.9 to 76.1
Sensation seeking	2	.86		41.0, 43.6
Self-efficacy for physical activity	8	.87	.56 to .78	42.9 to 70.5
Physical activity enjoyment	10	.92	.58 to .85	53.9 to 75.6
Sedentary behavior enjoyment (screen-based)*	4			
Sedentary behavior enjoyment (non-screen-based)	4	.89	.57 to .84	54.2 to 66.4
Parental support for physical activity	2	.79		31.3, 34.8
Psychological well-being	5	.80	.46 to .72	55.3 to 74.4
Physical well-being	2	.70		59.8, 66.1

*In the pilot questionnaire there were two separated scales for TV/DVD time and computer use. Both scales will be combined as overall screen-based sedentary behavior. Hence, there are no item characteristics available for this combined scale.

sensation seeking [50] as well as physical and psychological well-being [51]. The enjoyment of screen-based and non-screen-based sedentary behaviors will be assessed with four adapted items of the PACES [49] (non-screen-based sedentary behavior: $r = .59$). The scale "depressed affect" of the German version of the Center for Epidemiological Studies Depression Scale for Children CES-DC [52,59] and three items to assess the intention for physical activity were added to the questionnaire after the pilot study. Thus, students will be asked how much they agree with three given statements, (for example: "I plan to be physically active for at least 60 minutes per day on most days of the next week.," seven-point semantic differential scale from "likely" to "unlikely") [53].

Social variables Parental support for physical activity will be assessed by an adapted version of a scale used by Trost *et al.* [25] ($r = .80$). Furthermore, students will be asked how many of their friends are physically active regularly (5-point scale: "none" to "all", $r = .72$), how many are in a sports' club (5-point scale: "none" to "all", $r = .69$), how important it is in their circle of friends to be physically active (4-point scale: "not important" to "very important", $r = .50$) and how often their parents were physically active without them in the past week (5-point scale: "never" to "more than five times", $r = .78$). Two items will be used to obtain information about the environmental situation to be physically active: "In my neighborhood there are many facilities in which for being physically active." (5-point scale: "strongly disagree" to "strongly agree", $r = .60$) and "When I want to do sports, facilities and equipment are lacking." (5-point scale: "never" to "always", $r = .70$). Finally, normative expectations of physical activity and screen time will be assessed. Therefore, students will be asked for their estimation of

the portion of adolescents that are physically active for 60 minutes on a daily basis ($r = .60$) and how many hours per day adolescents spend watching TV or on the computer ($r = .61$).

Qualitative methods

In addition to and in combination with quantitative methods, a qualitative analysis of processes and outcomes of the "läuft." program will be performed. During the program, document analyses of students' entries on the homepage will be conducted. Group discussions with students will be carried out in the course of the post-assessment.

Document analysis To gain insights into processes of the intervention immediately, a qualitative document analysis of activities on the "läuft." homepage will be conducted. The homepage can be used by students to take part in the creativity contest, compete with their amount of steps, share their individual experiences in the program, discuss program associated topics and participate in weekly tasks. Students' activities and entries on the homepage will provide information about the activating-strategies that will be used and developed during the intervention.

Group discussion (students' perspective) In order to obtain a deeper understanding of students' experiences, motives and interpretations of given impulses and activating-strategies during the program, group discussions with selected members of each intervention class will be conducted in the course of the post-assessment. On the basis of a theoretical sampling [60], five to seven students differing with regard to (a) gender, (b) interest in and commitment to the "läuft." program and (c) athleticism

will be asked to participate in the group discussions. These will follow a thematic compendium and will be carried out in accordance with the principles of Bohnsack [61], which emphasize the self-deployment of the group and the minor impact of the researcher on group processes.

Process evaluation

To evaluate the quality of implementation, teachers will be asked to fill in questionnaires about the realization of each intervention component during the program. Information about acceptance, feasibility and suggestions for improving the program will be provided by another questionnaire for all participating teachers after the intervention and interviews with selected teachers. The latter will additionally enable a more profound and case-oriented analysis of interaction processes, barriers and success strategies. The teachers will be selected using theoretical sampling based on results of the questionnaires as well as formal criteria (for example, gender and type of school).

Statistical analysis

Statistical analysis will be conducted with Stata V13.1 (Stata Corp, College Station, TX, USA) following the intention to treat principle. To evaluate efficacy of the program, multilevel analysis with the levels: schools, classes, individuals and waves, will be performed. Random intercepts will be included for schools, classes and individuals taking the clustering effect into account. Group and covariates will be taken as fixed effects. Differences between intervention and control group at baseline as well as attrition analysis will be examined using a t-test for independent samples and Fisher's exact test.

Qualitative analysis

Qualitative data will be analyzed using ATLAS.ti software (ATLAS.ti GmbH, Berlin, Germany). Following basic methodological principles of the qualitative content analysis [62] and coding strategies of the grounded theory approach [63], relevant categories will be generated, systemized and summarized to permit thorough interpretations of participants' opinions and experiences.

Discussion

The described study protocol is intended to evaluate the efficacy of the "läuft." physical activity program to enhance physical activity of adolescents using a two-arm three-wave cluster randomized controlled trial. "läuft." is a school-based program addressing an age group - adolescents aged 13 to 15 years - in which the level of physical activity declines dramatically [13,14]. Thus, to accomplish an increase of the basic physical activity level in everyday life the intervention is targeted on four different components: individual, class, school and parents.

In the promotion of physical activity in adolescence, a multicomponent approach and interventions in the school setting have been proven to be most promising and successful strategies [15]. Considering the easy access to students from all levels of society and the long period of time they spend in school, health programs in the school setting can effectively reach a large number of adolescents. On the other hand, many school-based interventions were insufficient in enhancing not just in-school but also out-of-school physical activity [17,18]. The "läuft." physical activity program tries to overcome this shortcoming by changing students' everyday routine by using pedometers throughout the entire day. Moreover, pedometers have been proven to increase physical activity also in low-active adolescents [21,22] who are at high risk of adiposity, and poorer cardiovascular health and fitness [64]. The implementation of a follow-up assessment 12 months after the program ends, takes into account that interventions for promoting physical activity in adolescents are mostly limited to rather short-term effects [17]. Considering four educational lessons over a period of 12 weeks, time and effort for participating teachers are rather low. Indeed, the intervention might not be intensive enough to lead to major improvements in cardiovascular risk factors, such as BMI or blood pressure, but the low threshold for successful participation might also cause better acceptance. Students do not need to be athletic or of normal weight to achieve a high number of steps.

Nevertheless, universally applied programs also include students that are already sufficiently physically active. Thus, not all resources will be used efficiently. As the main limitation of the presented study, physical activity will be assessed by using self-administered questionnaires and will not be measured objectively through accelerometers. Even though, with respect to adolescents, reliability and validity of self-administered recall-questionnaires are acceptable to good [65]; aiming for triangulation of quantitative and qualitative research methods, the qualitative results pose an opportunity to reach a better and deeper understanding of the barriers and prospects of a "successful" intervention and aspired sustainability. Suitable strategies and options can be deducted from the quantitative-qualitative data and lead to concrete recommendations for future implementation.

Trial status

At the time of manuscript submission (September 2013), the school recruitment was about to begin and will finally be started in October 2013. First data assessment will start in 2014.

Abbreviations

BMI: Body mass index; CES-DC: Center for epidemiological studies depression scale for children; ICC: Intraclass correlation coefficient; PACES: Physical activity enjoyment scale; r: Retest-reliability.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

RH is the principal investigator. RH and BI supervise the study. RH, BI, JH, CK, BW and JS took part in the study concept and design. RH, BI, JH, MJ, KM, VS, IS and CK were responsible for the intervention concept. IS, MJ and BW were responsible for determination of the medical assessment procedure. MJ and IS were responsible for the determination of physical testing. VS, BI and RH constructed the questionnaire. KM and CK determined the qualitative methods. MJ, VS, KM, IS, BI and CK acquired the data during the pilot study. VS and BI analyzed the statistical data of the pilot study. KM and CK analyzed the qualitative data of the pilot study. VS, KM, MJ, IS, BI, CK and RH interpreted the data of the pilot study. VS and JH drafted the manuscript. RH, BI, MJ, KM, CK, IS, BW and JS performed the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

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3.5 Manuskript 4 – Ergebnisse einer Evaluationsstudie zur Wirksamkeit der schulbasierten Intervention „läuft.“

Prospective effects of pedometer use and class competitions on physical activity in youth: a cluster-randomized controlled trial

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Abstract

Objective: To evaluate the immediate effects of a school-based multi-component program to foster a physically active lifestyle in adolescence.

Design/Participants: In a cluster-randomized controlled trial with pre- and post-assessment in 2014, 29 schools with 1,162 8th grade students (48% girls) from Germany were included. Age ranged from 12 to 17 years (M=13.74; SD=0.67).

Intervention: While the control group attended education as usual, students in the intervention group received pedometers and took part in a class competition over a time period of 12 weeks. Classes with the most steps and best creative ideas to promote physical activity in everyday life were awarded.

Main outcome measures: Primary outcomes included out-of-school sports activities (h/week), moderate to vigorous physical activity (d/week with a minimum of 60 minutes), active commuting (min/day), doing chores (min/day), and sedentary behavior (h/day) assessed through self-administered questionnaires as well as cardiorespiratory fitness measured using the 20m shuttle-run test (completed laps).

Results: Significant interaction terms between group and wave of assessment were found on out-of-school sports activities (b=-1.09 [-1.89; -0.29], p=0.008), moderate to vigorous physical activity (b=-0.29 [-0.47; -0.10], p=0.002), and active commuting (b=-20.41 [-32.32; -8.49], p=0.001): students in the intervention group showed a higher increase of physical activity levels than students in the control group. The intervention effect on cardiorespiratory fitness missed significance marginally (b=-1.52 [-3.14; 0.98], p=0.065), There was no effect on students' sedentary behavior (b=0.06 [-0.72; 0.84], p=0.881).

Conclusions: An easy to administer school-based physical activity program (12 weeks) may enhance students' leisure-time physical activity.

Trial registration number: ISRCTN49482118

Introduction

Physical activity (PA) in childhood and adolescence benefits physical and mental health (Janssen & LeBlanc, 2010; Ahn & Fedewa, 2011; Andersen, Riddoch, Kriemler, & Hills, 2011). Moreover, physically active youth have higher levels of PA and fewer cardiovascular risk factors in adulthood (Malina, 2001; Telama, 2009; Twisk, Kemper, & van, 2002; Hasselstrom, Hansen, Froberg, & Andersen, 2002). The World Health Organization (WHO) recommends 60 minutes of moderate to vigorous physical activity (MVPA) per day for children and adolescents to enhance and maintain health (World Health Organization, 2010). Nevertheless, in Western societies most of them fall short of these global guidelines (Ekelund et al., 2012; Bucksch, Inchley, Hamrik, Finne, & Kolip, 2014). For instance, only 14.8% of German children and adolescents aged 11-13 years meet the WHO recommendations in 2012; at 14-17 years that percentage declines to 11.5% (Manz et al., 2014). Nader et al. (2008) reported a decline of MVPA from 180 minutes per day at the age of 9 years to only 42 minutes per day at the age of 15 years in US children and adolescents. In contrast, time spent with sedentary leisure-time activities increases from younger to older ages (Pate, Mitchell, Byun, & Dowda, 2011; Bucksch et al., 2014). Several studies found only a small inverse relationship between sedentary behavior (SB) and MVPA, whereas the relationship with total PA was found to be strong (Ekelund et al., 2012) SB emerged as a health risk factor that is independent of adolescents' MVPA (Biddle & Asare, 2011; Mitchell, Pate, Beets, & Nader, 2013; Santos et al., 2014; Tremblay et al., 2011). Since there are additional adverse joint effects of low levels of MVPA and high levels of SB on adolescents' health (de Moraes et al., 2013; Santos et al., 2014), the need for fostering and establishing a more active lifestyle during adolescence, i.e. both a high level of MVPA and a low level of SB, is of

major importance in modern societies. In addition, only about 60% of European adolescents achieve a healthy level of cardiorespiratory fitness (Ortega et al., 2011).

School-based multicomponent interventions involving peers, parents and communities have been reported to be a promising approach to enhance PA in youth (Kriemler et al., 2011; van Sluijs, McMinn, & Griffin, 2008). Meta-analyses and reviews indicate that school-based interventions promote PA and have positive impacts on health-related indicators, namely an increased rate and duration of in-school PA as well as aerobic fitness and a decrease of SB and of blood cholesterol (De Meester, van Lenthe, Spittaels, Lien, & de Bourdeaudhuij, 2009; Kriemler et al., 2011; van Sluijs et al., 2008; Dobbins, Husson, Decorby, & LaRocca, 2013). While these outcomes are encouraging, one substantial limitation was encountered: school-based PA programs mostly fail to increase out-of-school PA as well (De Meester et al., 2009; van Sluijs et al., 2008). Use of pedometers is one successful element in interventions aimed at fostering PA. In a review by Lubans et al. (2009), pedometer use resulted in twelve of fourteen studies in a significant improvement of PA. Using pedometers enables students to track their own activity levels. In combination with successful behavior change strategies such as goal-setting, self-monitoring and social support (Michie, Abraham, Whittington, McAteer, & Gupta, 2009; Ory, Jordan, & Bazzarre, 2002), using pedometers is effective in enhancing PA (Kang, Marshall, Barreira, & Lee, 2009; Lubans, Morgan, & Tudor-Locke, 2009) not just in school but also out of school (Lubans & Morgan, 2008; Schofield, Mummery, & Schofield, 2005). The PA program “läuft.” (“walks/runs”) integrates these behavior change strategies as well as pedometer use in a multicomponent school-based intervention. In addition to pedometers main components of the “läuft.” program are

class competitions. Acting on the class level provides social support from peers which is an important determinant for PA in adolescence (Silva, Lott, Mota, & Welk, 2014) and might change social norms within the peer group by rewarding the most physically active classes. "läuft." focuses especially on increasing out-of-school PA of different intensities and in different contexts as well as on establishing an active lifestyle in the long term.

By accumulating a higher level of total PA the time spent with SB might decrease, since studies found a strong inverse association between both behavioral categories (Ekelund et al., 2012). In addition, a reduction of SB might be caused by on the one hand making PA more attractive by enhancing its reinforcing value through class competitions, and on the other hand diminish the perceived effort to engage in PA by making it easy to administer in everyday life as well (Epstein & Roemmich, 2001; Epstein, Roemmich, Paluch, & Raynor, 2005). Improvements of students' cardiorespiratory fitness are assumed to be another side-effect of increased PA levels. High as well as light intensity PA are associated with cardiorespiratory fitness in young adolescents (Denton et al., 2013).

The aim of the current study is to present immediate intervention effects of the cluster randomized controlled trial "läuft.". Hypothesized effects on primary outcomes in the intervention compared to the control group were tested on the individual level, and are defined as: 1) increase of PA of different intensities and in different contexts, 2) decrease of leisure-time SB, and 3) increase of cardiorespiratory fitness.

Methods

Intervention

“läuft.” is a 12 week school-based PA program targeting students aged 12 to 15 years. A detailed description of “läuft.” is given in the study protocol (Suchert et al., 2013). Briefly, all students received pedometers (Omron Walking Style One 2.1) to evaluate their daily PA. They documented their steps as well as their experiences during the program using an interactive user account on the project homepage (www.laeuft.info). The core components of the intervention were two class competitions: 1) In three selected weeks classes averaged all steps to a class mean and sent it to project staff. Classes with the highest means of steps per week as well as with the largest increase were awarded with cash prizes. 2) Each class collected creative and inventive ideas on how to increase PA in everyday school life, kept record of these ideas, and sent them to project staff. Classes with the most inventive and creative class projects were awarded as well. In addition, classes participated in four 45 minutes educational lessons which were provided in an elaborated manual and implemented by one or two teachers. These lessons aimed at introducing both competitions, giving and creating ideas how to integrate PA in everyday life and reflecting strategies to be more physically active. The headmaster and entire teaching staff of participating schools received information material including background and description of the program, activity-promoting teaching methods and suggestions on how to improve the school environment to stimulate PA. Furthermore, parents received information material about the intervention and about ideas on how to support their children in establishing a physically active lifestyle.

Study Design

In a cluster-randomized controlled trial (ISRCTN49482118) the effectiveness of the “läuft.” PA program will be evaluated by conducting three waves of assessment: 1) before intervention in January/February 2014, 2) immediately after the intervention in June/July 2014, and 3) one year after the end of intervention in June/July 2015. The current study examines data from the first and second assessment. To avoid interferences between intervention and control group, schools were the level of clustering. A stratified randomization was carried out on the school level (according to the type of school and number of 8th grade classes) with the computer program Randomization In Treatment Arms (RITA) (Pahlke, König, & Ziegler, 2004). Randomization followed a 3:2 ratio, that is, each school had a 3:2 chance of being assigned to the intervention group, because a higher drop-out was expected in the intervention group. The ethics committee of the German Psychological Society and the Ministry of School and Professional Education of Land Schleswig-Holstein approved this study.

Sample size calculation

Before power calculation, the clustering effect was estimated as $1 + (m-1)p$, where m is the average number of subjects per cluster and p the intraclass correlation coefficient (ICC) (Murray, Varnell, & Blitstein, 2004). Assuming an equal average cluster size of 20 pupils with parental consent ($m= 20$) and an ICC of approximately 0.05 (Kriemler et al., 2010; Zahner et al., 2006), a clustering effect of 1.95 was determined. The study was powered to detect a small to medium effect size of the intervention on PA, applying a significance level of $\alpha=0.05$ and $\text{power}=0.80$ accounting for a cluster effect as well

as a drop-out rate of 25%. We estimated a total sample size of 911 students and 46 classes.

Participants and Procedure

In autumn 2013, all secondary schools in six districts of the federal state of Schleswig-Holstein in Germany (N=134) were invited to participate with their 8th grade classes. Of these, 29 schools with 61 classes and 1,489 students decided to take part in the study. Eighteen schools were allocated to intervention and eleven schools to control group. We obtained informed parental consent to the storage and use of assessed data prior to baseline-assessment where data of 1,296 students were collected. Missing data were due to missing parental consent (N=136) and absenteeism (N=52). In single cases students had left class or school between recruitment and baseline assessment (N=5). All assessments were conducted during regular school hours, first in the classroom (questionnaires) and afterwards in the gymnasium (medical and fitness testing). The “läuft.” PA program was conducted from March to May 2014 in the intervention group while classes in the control group received no further intervention. Data for 1,287 students were assessed during post-assessment. There was no drop-out on school or class level. Data for 1,162 students were matched with baseline data. The study sample included 558 girls (48.0%) and ranged 12-17 years (M=13.74; SD=0.67). A flow chart of participants is presented in Figure 1.

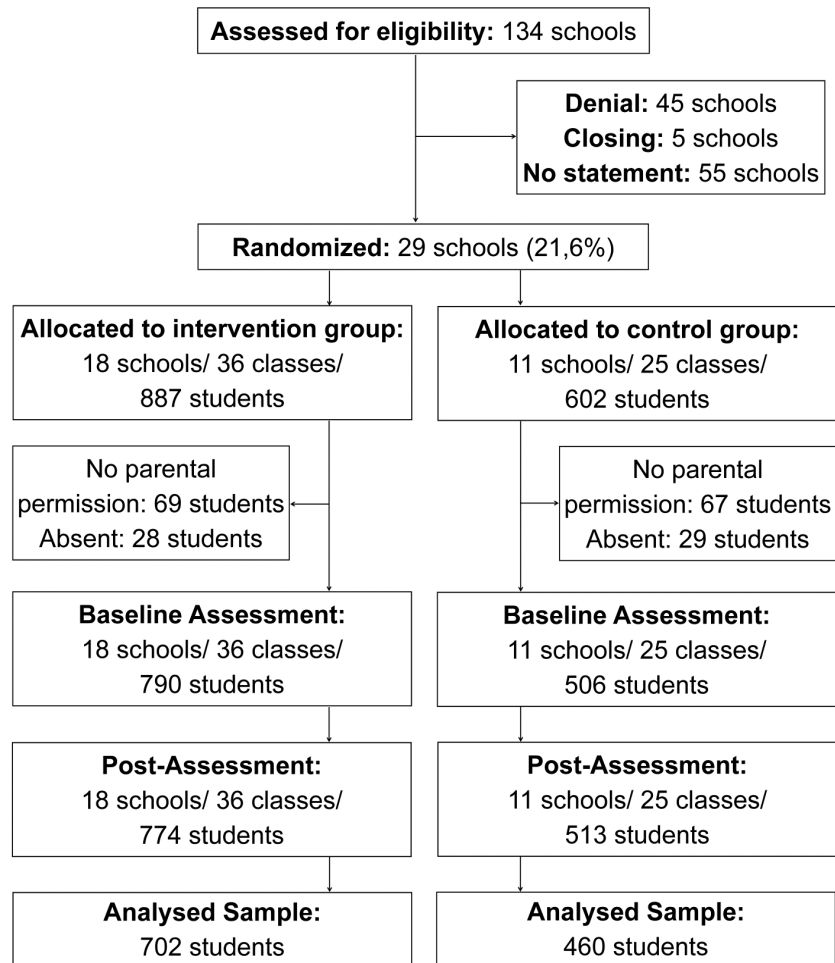


Figure 1: Flow chart of recruitment, randomization and participation of adolescents in the cluster-randomized controlled trial "läuft."

Outcome Measures

All outcomes were assessed on individual level. A reliable and validated two-item screening measure by Prochaska and colleagues (2001) was used to assess compliance with WHO guidelines. Students were asked on how many days of the last week and of a usual week they spent at least 60 minutes with *moderate to vigorous physical activity* (activities that make them breathe faster and increase their heart rate). Both scores were averaged for statistical analyses (days/week).

To measure *out-of-school sports activities*, adolescents indicated how many hours in a usual week they are doing sport in sports clubs including training and competitions/matches as well as in their leisure-time out of sports clubs. They should only relate to activity bouts lasting for a minimum of 15 minutes. Numbers of hours in both contexts were determined on an accuracy of half an hour and summed up to a total amount of hours per week.

An adapted version of the survey method by Zabinski and colleagues (2007) was used to measure adolescents' leisure-time *sedentary behavior*. Students indicated how many hours and minutes they spent with different activities during the most recent school day and the most recent Sunday. The following SB were included: watching TV/DVDs, playing video or computer games (except active electronic gaming), other leisure-time pursuits on the computer or mobile phone, passive transport, doing homework, reading, listening to music, creative hobbies, talking to others as well as any other sedentary activities. To determine an average daily amount of time spending with each activity minutes on weekday were multiplied by five and on weekend day by 2 and summed up. This summed score was then divided by 7. The average scores of all sedentary activities were summed up to a total amount of SB. The scores were cut down to a maximum of 24 hours. Unit of analyses were the average hours per day. Students who reported that they were sick on one of the days in question were excluded from statistical analyses. Just as the measurement method of SB described above, *active commuting* and *doing chores* (household and garden) were assessed as indicators of everyday PA. Active commuting included walking as well as bicycling.

To measure *cardiorespiratory fitness* the 20m shuttle-run test (Leger, Mercier, Gadoury, & Lambert, 1988) was implemented. In this widely used field test participants run back and forth in a distance of 20 meters in a given time interval indicated by prerecorded audio signals. The required running pace starts with 8.0 km/h and continuously increases by 0.5 km/h each minute. The test stops either when students abandon by themselves or when they fail to reach the line by the sound for the second time. The total number of completed laps was used for statistical analyses.

Statistical Analysis

All statistical analyses were conducted with Stata 13.1 (Stata Corp, College Station, TX) following the intention-to-treat-principle. Multilevel mixed-effects logistic regression analyses were conducted to test for selective attrition between intervention and control group. Gender, age and each primary outcome as well as the interaction term between these variables and the group variable were entered as predictors into single regression analyses predicting whether students remained in the study or were lost to post-assessment. To test for baseline differences, t-test for independent samples and Fisher's exact test were used. Multilevel mixed-effects linear regression analyses were applied to evaluate effects of the intervention on primary outcome measures. Each outcome was regressed on group and wave of assessment as well as on the interaction term between both. Considered levels were school, class and individual. Mean scores for baseline and post-assessment as well as mean changes adjusted for these levels were determined for each group and outcome. In addition, Cohen's d as measure of effect size was calculated for each change score. In line with Cohen's suggestions (Cohen, 1988) $d=0,2$ meant a small, $d=0,5$ a medium, and $d=0,8$ a large

effect. Cases with missing data in the primary outcomes were excluded from the respective analysis (2.4% to 31.3%).

Results

Attrition analysis

Among the 1,287 students participating in the baseline assessment, data of 134 students were not available at post-assessment (10.4%). Students in the study sample engaged in less out-of-school sports activities at baseline than students lost to post-assessment ($p=0.006$). Attrition analyses revealed no further differences between study sample and students dropping out of the study. There was no selective attrition between intervention and control group.

Description of study sample and baseline comparison

Participants' characteristics at baseline are presented in Table 1. While there were no baseline differences regarding gender ($p=0.549$), parents' highest educational attainment ($p=0.576$), SB ($p=0.335$), active commuting ($p=0.055$) and doing chores ($p=0.090$), adolescents in the control group engaged in significantly more out-of-school sports activities ($p=0.002$) and MVPA ($p=0.001$) per week, completed more laps in the shuttle-run test ($p=0.041$), were significantly older ($p=0.029$), and were more likely to attend college-preparatory schools ($p<0.001$) than adolescents in the intervention group.

Table 1: Participant characteristics at baseline (Germany, 2014)

	Intervention group (n=702)	Control group (n=460)	p-value
Gender			0.549
Female	47.3%	49.1%	
Male	52.7%	50.9%	
Age	13.70 (SD=0.66)	13.79 (SD=0.68)	0.029
Type of school			<0.001
College-preparatory schools	39.2%	50.9%	
General/Secondary schools	12.8%	4.8%	
Comprehensive schools	48.0%	44.3%	
Parents' highest educational attainment			0.576
Attended no school or not exceeding 8 th grade	1.5%	1.5%	
Secondary school (10 th grade)	47.5%	50.8%	
General qualification for university entrance	51.0%	47.7%	
Days with at least 60 minutes of moderate to vigorous physical activity (days/week)	3.94 (SD=1.70)	4.27 (SD=1.63)	0.001
Out-of-school sports activities (h/week)	7.85 (SD=5.22)	9.05 (SD=6.54)	0.002
Active commuting (min/day)	50.02 (SD=61.33)	60.36 (SD=90.26)	0.055

Doing chores (min/day)	25.01 (SD=40.37)	30.39 (SD=51.13)	0.090
Sedentary behavior (h/day)	7.52 (SD=5.31)	7.90 (SD=6.11)	0.335
Completed laps in the shuttle-run-test	50.56 (SD=21.28)	53.34 (SD=21.95)	0.041

n, sample size; SD, standard deviation

Intervention effects

Results of the intervention effects are presented in Table 2.

There was a significant group by time interaction on MVPA ($b=-0.29$ [-0.47;-0.10], $p=0.002$). A significant positive change in days of MVPA was only observed in the intervention group. Days spent with MVPA among students in the control group remained almost the same from baseline to post-assessment. According to WHO guidelines (1h/day of MVPA), in the intervention group 6.5% of students met them at baseline and 11.3% after the intervention. In the control group the proportion of students meeting these guidelines increased from 8.3% to 9.0%.

There was a significant group by time interaction on hours spent with out-of-school sports activities as well ($b=-1.09$ [-1.89; -0.29], $p=0.008$). While leisure sports activities of students in the control group did not change from baseline to post-assessment, there was a significant increase among students in the intervention group.

The group by time interaction on active commuting reached significance ($b=-20.41$ [-32.32; -8.49], $p=0.001$). Only students in the intervention group increased the time of active commuting significantly from baseline to post-assessment. The time spent with doing chores as an indicator of everyday PA changed neither in the intervention nor in the control group. Thus, the group by time interaction was not significant as well ($b=-4.89$ [-11.64; 1.87], $p=0.156$).

Concerning the hours per day spent sedentary, there was no significant group by time interaction ($b=0.06$ [-0.72; 0.84], $p=0.881$). Students in both groups showed no change in SB from baseline to post-intervention.

The group by time interaction on the number of completed laps in the shuttle-run test failed significance marginally ($b=-1.52$ [-3.14; 0.98], $p=0.065$). In both groups students improved their performance significantly, but to a greater extent in the intervention group with an effect size of $d=0.39$. The effect size of change in the control group was $d=0.27$.

Discussion

In a cluster-randomized controlled trial the effects of the school-based multi-component intervention called “läuft.” on students’ PA, SB and cardiorespiratory fitness were evaluated. Overall, findings provide evidence for the effectiveness of “läuft.” on students’ out-of-school sports activities, weekly MVPA as well as active commuting, i.e. the intervention led to an increase of PA in the intervention group but not in the control group. Adolescents’ SB was not affected and cardiorespiratory fitness only marginally.

Previous research indicated that interventions in school settings following a multi-component approach are effective in enhancing PA (Kriemler et al., 2011). One shortcoming of the majority of school-based interventions was a missing effect on out-of-school PA, while they led to consistently more PA during school hours (2013). In the present study there were significant effects of the “läuft.” program on sports activities in sports clubs and in students’ unorganized leisure-time as well as on active commuting as an everyday activity. These effects might be due to the universal and open approach to PA in the “läuft.” program. Adolescents want to have free choices relating to type, timing, location and co-participation of PA (Corder, Atkin, Ekelund, & van Sluijs, 2013).

Table 2: Adjusted mean scores and changes in outcomes from baseline to post-intervention as well as main and interaction effects of group and time (Germany, 2014)

Outcome [ICC]	Group	Baseline		Post-intervention		Change over time		Group by time interaction p-value
		M (SE)	M (SE)	M (SE)	M (SE)	p-value	d	
MVPA (d/week) [0.057]	Control	4.30 (0.13)	4.39 (0.13)	0.10 (0.07)	0.191	0.07	0.002	
	Intervention	3.98 (0.10)	4.37 (0.10)	0.38 (0.06)	<0.001	0.24		
Out-of-school sports activities (h/week) [0.055]	Control	9.18 (0.47)	9.72 (0.46)	0.55 (0.32)	0.086	0.09	0.008	
	Intervention	7.89 (0.38)	9.53 (0.38)	1.64 (0.26)	<0.001	0.26		
Active commuting (min/day) [0.050]	Control	62.98 (5.57)	61.89 (5.55)	-1.09 (4.67)	0.815	-0.01	0.001	
	Intervention	51.29 (4.58)	70.60 (4.60)	19.31 (3.89)	<0.001	0.23		
Chores (min/day) [0.029]	Control	29.91 (2.97)	26.70 (2.96)	-3.20 (2.65)	0.226	-0.07	0.156	
	Intervention	26.30 (2.44)	27.98 (2.45)	1.68 (2.20)	0.445	0.04		

Sedentary behavior (h/day)	Control	7.81 (0.55)	7.63 (0.55)	-0.18 (0.31)	0.555	-0.03	0.881
	Intervention	7.70 (0.44)	7.46 (0.44)	-0.24 (0.25)	0.346	-0.04	
Completed laps in the shuttle-run test [0.154]	Control	53.45 (2.84)	56.92 (2.85)	3.47 (0.64)	<0.001	0.27	0.065
	Intervention	51.45 (2.24)	56.44 (2.25)	4.99 (0.52)	<0.001	0.39	

MVPA, moderate to vigorous physical activity; M, adjusted mean score (adjusted for multilevel structure of data); SE, standard error; d, effect size of the change score (Cohen's d); ICC, intraclass correlation

In the “läuft.” program each student could choose when, what type and with whom he/she wants to be physically active in order to collect more steps. “läuft.” intended to enhance PA of all intensities and especially in different contexts. In addition, the application of pedometers enables students to track and evaluate their PA throughout the entire day. In other studies pedometers were effective in enhancing PA out-of-school as well (Lubans et al., 2009). Furthermore, acting on the class level might influence social norms in the peer group as an important determinant of adolescents’ health behavior (de la Haye, Robins, Mohr, & Wilson, 2010; Sawka, McCormack, Nettel-Aguirre, Hawe, & Doyle-Baker, 2013; Silva et al., 2014). However, another everyday activity, namely doing chores in household and garden, was not affected by the “läuft.” intervention. It might be that because of their discontinuous manner and the predominant standing position those activities are not effective for collecting steps and thus, students in the intervention group did not engage in them more often than students in the control group.

The intervention “läuft.” was supposed to reduce SB by enhancing total PA, since both have been shown to be strong inversely associated with each other (Ekelund et al., 2012). However, the absence of an intervention effect on SB might be due to a predominant enhancement of MVPA and not necessarily light intensity PA as well. The former is only moderately associated with SB. The focus of “läuft.” on enhancing PA could be another reason for not changing the time students engage in sedentary leisure-time pursuits. There was no intervention component addressing sedentary time in particular. A Cochrane review (Dobbins et al., 2013) which summarized the effects of school-based PA interventions in youth included three studies assessing impacts on

adolescents' television viewing. Only one of them that included components dealing with screen viewing alongside of PA reported significant intervention effects (Singh, Chin, Brug, & van, 2009). Another systematic review (DeMattia, Lemont, & Meurer, 2007) about the effects of limiting SB in youth identified two school-based interventions addressing adolescents with significant effects on screen viewing. Thus, intervention components tailored to decrease SB are supposed to be necessary for the reduction of the time spent sedentary. Furthermore, there seems to be combined beneficial effects of exercise training and the reduction of SB on cardio-metabolic health markers, since both act as independent risk factors (Keadle et al., 2014).

The increased number of laps in the shuttle-run test in both groups might be due to learning effects and changed weather conditions from winter to summer. Even though the group by time interaction missed significance, there was a tendency that students in the intervention group improved their results in the shuttle-run test to a greater extent than those in the control group. Studies included in the review by Kriemler et al. (Kriemler et al., 2011) showed significant intervention effects on cardiorespiratory fitness. All of these studies implemented a number of PA sessions each week which are conducted by physical education specialists (Kriemler et al., 2011). Teachers of other school subjects than sports implemented the "läuft." program as well and it did not include organized sports lessons. There was no minimum duration, rate or intensity of PA each student had to engage in. Nevertheless, using pedometers and class competitions as main impulses was enough to enhance students' PA, and thereby their cardiorespiratory fitness to some extent. More intensive interventions and a longer time period might be necessary to induce significant results on cardiorespiratory fitness.

Strengths and limitations

The presented evaluation study followed a systematic prescribed protocol with a large sample size using rigorous statistical analyses which considered the clustering of data. There was no drop-out on school or class level. An important strength of the intervention is the low level of effort for participating teachers, and the universal approach to PA. However, several limitations should be pointed out as well. PA and SB were only assessed through self-administered questionnaires which could lead to biased information. Information might be more likely biased in favor of intervention group since students received targeted messages about the benefits of PA. Another drawback is the difference of PA between intervention and control group at baseline. Even though all schools were randomly allocated, students in the control group participated in more out-of-school sports activities and weekly MVPA than students in the intervention group. These baseline differences were taken into account by including baseline scores in all regression analyses.

Conclusion

Results indicate that even an easy to administer intervention might be able to enhance students' PA in their leisure-time by focusing on PA in all intensities and different contexts. On the other hand, future school-based PA programs should include tailored components addressing the reduction of sedentary time as well, since SB is an independent health risk factor in modern societies. In a next step, it is important to evaluate the sustainability of the effects of the "läuft." program in a one-year follow-up-assessment.

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4 DISKUSSION

Das Ziel der vorliegenden Dissertation war einerseits, den aktuellen Forschungsstand zum Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter zusammenzufassen sowie differenzierte Assoziationen von bildschirmgebundenen und bildschirmungebundenen sitzenden/liegenden Verhaltensweisen zu untersuchen. Andererseits sollte ein schulbasierter Ansatz zur Bewegungsförderung und Reduktion von *Sedentary Behavior* bei Jugendlichen evaluiert werden. Im Folgenden werden die Ergebnisse der einzelnen Studien in die bestehende Literatur eingeordnet sowie Stärken und Limitationen diskutiert. Des Weiteren sollen die Einzelergebnisse zusammengeführt sowie Schlussfolgerungen gezogen werden.

4.1 Zusammenfassung und Einordnung der Ergebnisse sowie Stärken und Limitationen

4.1.1 Manuskript 1 – Systematische Übersichtsarbeit zum Zusammenhang zwischen *Sedentary Behavior* und Indikatoren der psychischen Gesundheit im Kindes- und Jugendalter

Basis der systematischen Übersichtsarbeit zum Zusammenhang von *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter bildeten 91 Studien, welche durch die systematische Suche in sechs elektronischen Datenbanken sowie Literaturverzeichnissen relevanter Artikel und der persönlichen Literaturlisten identifiziert werden konnten. Die Datensynthese ergab, dass vor allem bildschirmgebundenes *Sedentary Behavior* mit mehr Aufmerksamkeits- und Hyperaktivitätsproblemen und internalisierten Störungssymptomen sowie mit weniger psychischem Wohlbefinden/Lebensqualität verbunden war. Hinsichtlich der depressiven Symptome, der mit Essstörungen assoziierten Symptome, des Selbstwerts und der Angstsymptome ergab sich kein klarer Zusammenhang mit *Sedentary Behavior*. Unter Berücksichtigung der Qualität der Primärstudien zeigte sich jedoch eine negative Assoziation zwischen der Bildschirmzeit und dem Selbstwert. Die inkonsistenten Befunde bezüglich einiger untersuchter Indikatoren könnten vor allem auf mögliche Moderatorvariablen, wie beispielsweise das Geschlecht, zurückzuführen sein.

Insbesondere Kinder und Jugendliche, die sehr viel Zeit mit bildschirmgebundenen sitzenden/liegenden Verhaltensweisen verbrachten, wiesen eine schlechtere psychische Gesundheit auf.

Diese Ergebnisse stehen im Einklang mit den Befunden der Übersichtsarbeiten von Tremblay et al. (2011) und Costigan et al. (2013), welche jedoch in erster Linie die Assoziation zwischen bildschirmgebundenen sitzenden/liegenden Verhaltensweisen und der physischen Gesundheit untersuchten und eine vergleichsweise geringe Anzahl an Studien zur psychischen Gesundheit berücksichtigten. Damit liefert die vorliegende Übersichtsarbeit in Tiefe und Breite einen erweiterten systematischen Überblick des bisherigen Forschungsstandes und wichtige Informationen für zukünftigen Forschungsbedarf (siehe Abschnitt 4.3)

Von den insgesamt 91 in der Übersichtsarbeit eingeschlossenen Studien adjustierten elf die Ergebnisse für das Ausmaß an körperlicher Aktivität. Es zeigte sich eine von der körperlichen Aktivität unabhängige negative Assoziation mit zumindest einem Indikator der psychischen Gesundheit. Auch wenn die Anzahl der Studien, die den Zusammenhang von *Sedentary Behavior* mit der psychischen Gesundheit um den Einfluss der körperlichen Aktivität bereinigten, eher gering ist, scheinen sich sitzende/liegende Verhaltensweisen auch im Bereich der psychischen Gesundheit als zum Teil unabhängiger Risikofaktor herauszustellen. Die Ergebnisse der wenigen Längsschnitt- und Interventionsstudien deuten darauf hin, dass *Sedentary Behavior* durchaus ursächlich für eine schlechtere psychische Gesundheit sein könnte. Jedoch sind die Befunde hierfür noch nicht eindeutig. Schmitz und Kollegen (2002) berichteten beispielsweise, dass sich das Ausmaß an depressiven Symptomen als signifikanter Prädiktor für die Bildschirmzeit eineinhalb Jahre später erwies.

Das systematische Vorgehen nach dem PRISMA Statement (Liberati et al., 2009), welches a-priori definierte Ein- und Ausschlusskriterien beinhaltet, ist neben der umfassenden Fragestellung eine der wichtigsten Stärken dieser Arbeit. Problematisch war vor allem das querschnittliche Studiendesign der meisten eingeschlossenen Primärstudien. Dieses ließ keine Aussagen über die kausale Wirkrichtung zu und auch die Ergebnisse einzelner Interventions- und Längsschnittstudien waren inkonsistent. Für die Messung der Indikatoren der psychischen Gesundheit kamen häufig reliable und valide Instrumente zum Einsatz, die Erfassung des *Sedentary Behavior* erfolgte jedoch nur in wenigen Studien objektiv mit Hilfe von Akzelerometern. In vielen Studien wurde *Sedentary Behavior* über einzelne bildschirmgebundene sitzende/liegende Verhaltensweisen be-

ziehungswise einen kombinierten Wert für die Bildschirmzeit operationalisiert. Zudem war aufgrund der großen Heterogenität der Primärstudien keine quantitative Synthese möglich.

4.1.2 Manuskript 2 – bildschirmgebundenes versus bildschirmungebundenes Sedentary Behavior und Indikatoren des psychischen Wohlbefindens im Jugendalter

Bei Mädchen stellte sich *Sedentary Behavior* als ein von der moderaten bis intensiven körperlichen Aktivität unabhängiger Prädiktor für die psychische Gesundheit heraus. Es zeigte sich, dass bei Mädchen bildschirmgebundene, nicht jedoch bildschirmungebundene sitzende/liegende Verhaltensweisen negativ mit dem Selbstwert, dem psychischen Wohlbefinden sowie dem Selbstkonzept für physische Attraktivität assoziiert waren. Bezüglich der Depressivität ergab sich kein Unterschied: Sowohl bildschirmgebundenes als auch –ungebundenes *Sedentary Behavior* stand in positivem Zusammenhang mit der Depressivität. Bei Jungen zeigte sich ein weniger konsistentes Muster. Die Bildschirmzeit war bei ihnen positiv mit dem Selbstwert assoziiert und das bildschirmungebundene *Sedentary Behavior* positiv mit der Depressivität. Zudem zeigte sich ein u-förmiger Zusammenhang zwischen der Bildschirmzeit und der allgemeinen Selbstwirksamkeitserwartung.

Insgesamt decken sich die Befunde mit den Ergebnissen bisheriger Studien, die vor allem negative Assoziationen bildschirmgebundener sitzender/liegender Verhaltensweisen mit der psychischen Gesundheit fanden (Costigan et al., 2013; Eyal & Te'eni-Harari, 2013; Russ, Larson, Franke, & Halfon, 2009; Finne, Bucksch, Lampert, & Kolip, 2014). Allerdings gibt es eine Reihe an Studien, die negative Effekte des *Sedentary Behavior* auch bei Jungen berichtete (z. B. Calado, Lameiras, Sepulveda, Rodriguez, & Carrera, 2010; Kim, 2012), während diese in der vorliegenden Studie weitestgehend ausblieben. Dies könnte vor allem auf die geringere Prävalenz internalisierter Störungen bei Jungen (Durkin & Barber, 2002; Patton & Viner, 2007) sowie die geringe Varianz in den Indikatoren des psychischen Wohlbefindens in der vorliegenden männlichen Stichprobe zurückzuführen sein. Zudem konnte eine positive Assoziation zwischen bildschirmgebundenem *Sedentary Behavior* und der Qualität sozialer Beziehungen gefunden werden (Iannotti et al., 2009), die bei Jungen besonders ausgeprägt zu sein scheint (Finne et al., 2014). Das bedeutet, soziale Aspekte bildschirmgebundener sitzender/liegender Aktivitäten könnten insbesondere bei Jungen andere Indikatoren des psychischen Wohlbefindens positiv beeinflussen.

Zudem verbringen Jungen deutlich mehr Zeit mit Computerspielen, welche positiv mit dem Selbstwert assoziiert zu sein scheinen (Durkin & Barber, 2002). Dieser Effekt könnte vor allem durch die steigenden Anforderungen und Herausforderungen in Computerspielen begründet werden, deren Meisterung zu einer Steigerung des Selbstwerts führen kann (Subrahmanyam, Greenfield, Kraut, & Gross, 2001).

Bei den Mädchen stellte sich die Bildschirmzeit, nicht aber die bildschirmungebundene im Sitzen/Liegen verbrachte Zeit als Risikofaktor für das psychische Wohlbefinden heraus. Dabei könnten vor allem die vielfältigen Möglichkeiten des sozialen Vergleichs durch Fernsehen und Internet eine Rolle spielen. Das vorherrschende, häufig unrealistische Schönheitsideal westlicher Gesellschaften – schlank und attraktiv – hat für Mädchen und Frauen eine große gesellschaftliche Bedeutung (McKinley, 1999) und ist negativ mit dem physischen Selbstkonzept assoziiert (Eyal & Te'eni-Harari, 2013; Groesz, Levine, & Murnen, 2002). Die Identifizierung mit bevorzugten Charakteren in den Medien, welche häufig dünn und attraktiv sind, kann zur gesteigerten Wahrnehmung von Diskrepanzen zwischen dem eigenen Körper und den verbreiteten Idealen führen, was wiederum mit der Unzufriedenheit mit dem eigenen Erscheinungsbild sowie einem geringeren Selbstwert in Verbindung gebracht werden kann (Finne et al., 2014; Furnham, Badmin, & Sneade, 2002). Im Gegensatz zu diesen bildschirm-spezifischen Effekten zeigte sich hinsichtlich der Depressivität, dass sowohl bildschirmgebundenes als auch -ungebundenes *Sedentary Behavior* bei Mädchen positiv mit der Depressivität assoziiert war. Dies könnte auf einen eher generellen, möglicherweise auch physiologischen Mechanismus im Gegensatz zu den oben dargestellten medialen Einflüssen hindeuten. Zudem könnten Mädchen mit depressivem Affekt generell zu sitzenden/liegenden Verhaltensweisen tendieren.

Diese Studie ist eine der ersten, die gezielt Unterschiede zwischen bildschirmgebundenem und bildschirmungebundenem *Sedentary Behavior* im Jugendalter untersucht. Eine weitere Stärke ist, dass wichtige Störgrößen wie der Gewichtsstatus, das Geschlecht und vor allem auch das Ausmaß an moderater bis intensiver körperlicher Aktivität in den Analysen Berücksichtigung fanden. Die große Stichprobe erhöhte zudem die externe Validität der Ergebnisse. Eine wesentliche Limitation stellte allerdings die subjektive Messmethode zur Erfassung des *Sedentary Behavior* dar. Diese könnte zu Fehlklassifikationen geführt haben, da nicht jede Bildschirmzeit im Sit-

zen/Liegen verbracht wird und auch die Parallelnutzung verschiedener Medien zu Verzerrungen geführt haben könnte. Jedoch zeigte eine systematische Übersichtsarbeit von Pate und Kollegen (Pate et al., 2011), dass sich die Schätzungen des *Sedentary Behavior* zwischen Selbstangaben und objektiven Messverfahren wie Akzelerometrie nicht wesentlich unterscheiden. Zudem ermöglicht die Erfassung per Fragebogen eine Trennung zwischen Bildschirmzeit und bildschirmungebundenen sitzenden/liegenden Verhaltensweisen. Ein zusätzlicher Schwachpunkt ist das querschnittliche Studiendesign, da keine Kausalaussagen getroffen werden können. Auch die fehlende Erfassung externalisierter Störungen ist eine Schwachstelle der Studie, da internalisierte Störungen bei Mädchen deutlich häufiger auftreten als bei Jungen (Merikangas et al., 2009). Die Varianz in den erfassten Indikatoren war unter den männlichen Studienteilnehmer entsprechend gering.

4.1.3 Manuskript 3 und 4: Studienprotokoll und Ergebnisse einer Evaluationsstudie zur Wirksamkeit der schulbasierten Intervention „läuft.“

In einer cluster-randomisierten Kontrollgruppen-Studie wurden die unmittelbaren Effekte der schulbasierten Intervention „läuft.“ auf die körperliche Aktivität, das *Sedentary Behavior* sowie die kardiorespiratorische Fitness der teilnehmenden Schüler/innen untersucht. Die Intervention führte zu einer signifikanten Steigerung der körperlichen Aktivität außerhalb der Schule, des aktiven Transports und auch der Anzahl der Tage pro Woche mit mindestens einer Stunde moderater bis intensiver körperlicher Aktivität in der Interventionsgruppe im Vergleich zur Kontrollgruppe. Es zeigten sich jedoch keine Interventionseffekte auf das sitzende/liegende Verhalten oder die kardiorespiratorische Fitness der Schüler/innen.

Auch wenn sich bisherige schulbasierte Interventionen als erfolgreich erwiesen haben, körperliche Aktivität bei Kindern und Jugendlichen während der Schulzeit zu erhöhen, blieb ein Transfer in den außerschulischen Bereich häufig aus (Dobbins, Husson, Decorby, & LaRocca, 2013). Im Gegensatz dazu konnte „läuft.“ sowohl sportliche Aktivitäten außerhalb der Schule als auch die Zeit, in der die Schüler/innen Wege zu Fuß oder mit dem Fahrrad zurücklegten, erhöhen. Diese Effekte könnten sich auf den universellen Ansatz zu körperlicher Aktivität bei „läuft.“ zurückführen lassen. Im Zusammenhang mit körperlicher Aktivität wollen Jugendliche die freie Wahl haben, welche Bewegungsmöglichkeiten sie wann, mit wem und wo nutzen (Corder et al., 2013).

Diese Möglichkeiten sind bei „läuft.“ gegeben, da nicht zählt, wie die Schüler/innen ihre Schritte sammeln, sondern jegliche körperliche Aktivität, die zu einem aktiven Lebensstil beiträgt, entscheidend ist. Die Zeit, die die Schüler/innen mit Aufgaben im Haushalt und Garten als Indikatoren für Alltagsaktivitäten verbrachten, veränderte sich jedoch nicht. Dies ist vermutlich der Tatsache geschuldet, dass derartige Aktivitäten keine große Anzahl an zusätzlichen Schritten bringen.

Die Tatsache, dass „läuft.“ zwar eine Steigerung der körperlichen Aktivität, nicht jedoch eine Reduktion des *Sedentary Behavior* bewirkte, könnte zum einen an dem Fehlen spezifischer Interventionskomponenten für diese Reduktion liegen. In einer aktuellen Meta-Analyse, die die Effektivität von Interventionen zur Reduktion des *Sedentary Behavior* im Erwachsenenalter zusammenfasste (Prince, Saunders, Gresty, & Reid, 2014), berichteten die Autoren, dass Interventionen, die nur auf den Rückgang sitzender/liegender Verhaltensweisen abzielten, erfolgreicher waren als Interventionen, die als Hauptziel die Steigerung der körperlichen Aktivität hatten. Kombinierte Ansätze, die sowohl die Reduzierung von *Sedentary Behavior* als auch die Steigerung körperlicher Aktivität adressierten, lagen in ihrer Effektivität hinsichtlich der Verringerung sitzenden/liegenden Verhaltens zwischen diesen beiden einseitigen Herangehensweisen. Zum anderen war zwar der Transfer der Bewegungsförderung in den außerschulischen Bereich erfolgreich, jedoch scheint es sich hauptsächlich um eine Steigerung der moderaten bis intensiven körperlichen Aktivität zu handeln, die nur in moderatem negativen Zusammenhang mit dem *Sedentary Behavior* steht (Ekelund et al., 2012). Auch ist anzunehmen, dass der Einsatz subjektiver Messinstrumente für die Erfassung von *Sedentary Behavior* und der körperlichen Aktivität möglicherweise nicht hinreichend genau ist, um Verschiebungen von sitzender/liegender zu körperlich aktiver Zeit beobachten zu können.

Im Gegensatz zu anderen schulbasierten Programmen, die die kardiorespiratorische Fitness steigern konnten (Kriemler et al., 2011), unterschied sich die Verbesserung im 20m-shuttle-run-Test der Interventionsgruppe nicht signifikant von denen der Kontrollgruppe. Dies lässt sich vermutlich vor allem dadurch erklären, dass bisherige Studien ein festes Sportprogramm implementierten mit mehreren Sporteinheiten pro Woche, die von Sportlehrkräften oder externen Trainern durchgeführt wurden. Bei „läuft.“ hingegen ist keine feste Dauer, Häufigkeit oder Intensität an

körperlicher Aktivität vorgeschrieben und auch die durchführenden Lehrkräfte müssen keine Sportlehrkräfte sein. Zudem könnte die Zeitdauer von 12 Wochen zu kurz gewesen sein, um bereits signifikante Effekte auf die kardiorespiratorische Fitness nachzuweisen.

Als wesentliche Stärken der Evaluationsstudie „läuft.“ sind das systematische, im Vorwege protokollierte Vorgehen, die große Stichprobe und die strengen statistischen Analysemethoden, die auch die Clusterung der Daten berücksichtigten, zu nennen. Wichtiger Vorteil der Intervention sind der geringe Aufwand der Umsetzung sowie der universelle und offene Ansatz zu körperlicher Aktivität. Wichtige Limitation ist, dass sowohl körperliche Aktivität als auch *Sedentary Behavior* lediglich durch Fragebögen und nicht objektiv erfasst wurden. Außerdem lagen trotz randomisierter Zuordnung signifikante Baseline-Unterschiede hinsichtlich der körperlichen Aktivität zwischen Interventions- und Kontrollgruppe vor. Jugendliche in der Kontrollgruppe waren schon vor der Intervention körperlich aktiver. Die Kontrolle der Baseline-Unterschiede wurde durch die Aufnahme der Baseline-Werte in die statistischen Analysen realisiert.

4.2 Synthese und Schlussfolgerungen

Sedentary Behavior spielt im Leben von Kindern und Jugendlichen moderner Gesellschaften eine zentrale Rolle. Viele verbringen über die Hälfte des Tages mit sitzenden/liegenden Beschäftigungen, wobei insbesondere bildschirmgebundene Unterhaltungsmöglichkeiten wie Fernsehen oder die Nutzung von Computern hochprävalent sind (Hardy et al., 2006; Pate et al., 2011). *Sedentary Behavior* hat sich in den letzten 20 Jahren immer mehr als ein von der moderaten bis intensiven körperlichen Aktivität unabhängiger gesundheitlicher Risikofaktor im Kindes- und Jugendalter herauskristallisiert. Insbesondere die negativen Effekte, die ein hohes Ausmaß an *Sedentary Behavior* für die physische Gesundheit hat, sind gut belegt (Carson & Janssen, 2011; Ekelund et al., 2012; Mitchell, Pate, & Blair, 2012; Tremblay et al., 2011). Wie die Datensynthese der präsentierten systematischen Übersichtsarbeit nahelegt, scheint auch die psychische Gesundheit durch ein hohes Ausmaß an *Sedentary Behavior* beeinträchtigt zu werden. Die Befunde sind jedoch weniger eindeutig und konsistent. In Anbetracht der wenigen längsschnittlichen Studien ist es auch denkbar, dass Kinder und Jugendliche mit Beeinträchtigungen der psychischen Gesundheit sitzende/liegende Beschäftigungen bevorzugen.

Kritisch an vielen bisherigen Studien ist vor allem die Fokussierung auf bildschirmgebundene sitzende/liegende Verhaltensweisen sowie die häufig fehlende Kontrolle des Ausmaßes an körperlicher Aktivität in den Analysen. Die Ergebnisse der vorgestellten Querschnittsstudie zu Unterschieden in den Zusammenhängen zwischen bildschirmgebundenem und bildschirmungebundenem *Sedentary Behavior* legen differenzierte Assoziationen nahe. Bei Mädchen scheint insbesondere die Bildschirmzeit mit Beeinträchtigungen des psychischen Wohlbefindens in Zusammenhang zu stehen, während das sitzenden/liegende Verhalten bei Jungen insgesamt kaum eine Rolle in Bezug auf die untersuchten Indikatoren spielte. Das Geschlecht scheint eine moderierende Variable im Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit Jugendlicher zu sein. Die Unterscheidung zwischen bildschirmgebundenen und -ungebundenen sitzenden/liegenden Verhaltensweisen oder die Erfassung eines breiten Spektrums an *Sedentary Behavior* sollte für künftige Studien vorherrschend sein. Die präsentierten Zusammenhänge scheinen weitestgehend unbeeinflusst von dem Ausmaß moderater bis intensiver körperlicher Aktivität, was einen weiteren Hinweis für die Unabhängigkeit des *Sedentary Behavior* als gesundheitlichen Risikofaktor darstellt. Zukünftige Studien sind von Nöten, die die Ergebnisse dieser explorativen Studie zusätzlich mit objektiven Messverfahren untersuchen und eine größere Vielfalt an psychischen Beeinträchtigungen betrachten. Vor allem Jungen sind von internalisierten Problemen, wie sie in der vorliegenden Studie erfasst wurden, weniger stark betroffen als Mädchen (Patton & Viner, 2007).

Auch die Forschungsarbeit zu möglichen Variablen, die den Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit vermitteln, steht noch am Anfang. Zwar wurden diese in der vorliegenden Dissertation nicht geprüft, es scheinen jedoch verschiedene Mechanismen für unterschiedliche Indikatoren der psychischen Gesundheit beziehungsweise unterschiedliche sitzende/liegende Verhaltensweisen relevant zu sein. Es zeigte sich, dass die Depressivität bei Mädchen sowohl mit bildschirmgebundenen als auch -ungebundenen sitzenden/liegenden Verhaltensweisen positiv assoziiert war (Manuskript 2). Dieser Befund spricht für einen mit dem Sitzen/Liegen an sich verbundenen Mechanismus. Im Zusammenhang mit der physischen Gesundheit werden unter dem Begriff *Inaktivitätsphysiologie* biologische Mechanismen des Sitzens/Liegens untersucht und diskutiert (Hamilton, Healy, Dunstan, Zderic, & Owen, 2008). Auch bezüglich der Depressivität könnten mit langem Sitzen/Liegen assoziierte physiologische Prozes-

se eine Rolle spielen, wie sie im Bereich der körperlichen Aktivität bereits gefunden wurden (Fuchs & Schlicht, 2012). In Anbetracht des inversen Zusammenhangs von körperlicher Aktivität und *Sedentary Behavior* wird weiterhin die sogenannte *Ersetzungshypothese* diskutiert, das heißt, dass *Sedentary Behavior* die Zeit, die Kinder und Jugendliche andernfalls mit körperlicher Aktivität verbringen würden, ersetzt und damit die mit der körperlichen Aktivität assoziierten positiven Effekte für die psychische Gesundheit (Ahn & Fedewa, 2011; Biddle & Asare, 2011) entfallen beziehungsweise reduziert werden. Diese Hypothese scheint jedoch, wie die Ergebnisse der Evaluationsstudie nahelegen, nur begrenzt gültig zu sein. Zwar erhöhte sich das Ausmaß moderater bis intensiver körperlicher Aktivität bei den teilnehmenden Jugendlichen der Interventionsgruppe, das sitzende/liegende Verhalten blieb jedoch unverändert (Manuskript 4).

Während diese beiden Hypothesen vor allem für das gesamte *Sedentary Behavior* wirksam sein könnten, sprechen die Ergebnisse, insbesondere der Querschnittsstudie, für andere Erklärungen, die spezifisch für die Bildschirmzeit sind. Bei Mädchen war bildschirmgebundenes, nicht aber bildschirmungebundenes *Sedentary Behavior* negativ mit dem Selbstwert, dem physischen Selbstkonzept sowie der allgemeinen Selbstwirksamkeitserwartung assoziiert. Schon lange in der Kritik stehen die häufig unrealistischen medialen Schönheitsideale von dünnen, attraktiven Frauen und muskulösen Männern, die zu Unzufriedenheit mit dem eigenen Aussehen und einem geringen Selbstwert führen können (Eyal & Te'eni-Harari, 2013; Finne et al., 2014). Das Fernsehen und vor allem auch das Internet sowie die sozialen Medien bieten zahlreiche Vergleichsmöglichkeiten nicht nur hinsichtlich des eigenen Aussehens, sondern auch bezüglich verschiedenster Erfahrungen und Fähigkeiten. Solch ein ständiger sozialer Vergleich könnte ebenfalls zu Diskrepanzen zwischen den medial präsentierten Idealen und dem realen Erscheinen und Erleben der Jugendlichen führen und mit Unzufriedenheit sowie sozialem Druck assoziiert sein.

In der systematischen Übersichtsarbeit wurde zudem ein starker Zusammenhang von *Sedentary Behavior* und Aufmerksamkeits- beziehungsweise Hyperaktivitätsproblemen gefunden. Der vermittelnde Mechanismus ist hierbei noch unklar. Eine mögliche Hypothese ist, dass sich Kinder und Jugendliche, die viel fernsehen, Internet und Videospiele nutzen, an die schnellen Eindruckswechsel gewöhnen und dadurch vermehrt Schwierigkeiten haben, ihre Aufmerksamkeit dem deutlich langsameren „echten Leben“, beispielsweise in der Schule, zu widmen (Christakis,

Zimmerman, DiGiuseppe, & McCarty, 2004). Die Tatsache, dass fast alle der in der Übersichtsarbeit eingeschlossenen Studien die Bildschirmzeit der Kinder und Jugendlichen betrachteten, steht dieser Hypothese nicht entgegen, kann sie jedoch auch nicht bestätigen. Des Weiteren konnte ein hohes Ausmaß an bildschirmgebundenen sitzenden/liegenden Verhaltensweisen mit einer ungesünderen Ernährung (Boynnton-Jarrett et al., 2003) und dem Konsum von kalorienreichen Zwischenmahlzeiten (Blass et al., 2006) sowie Indikatoren für Übergewicht (Tremblay et al., 2011) in Verbindung gebracht werden. Diese wiederum scheinen im Zusammenhang mit einem geringeren Selbstwert, mehr depressiven Symptomen, einer geringeren Lebenszufriedenheit sowie Aufmerksamkeits- und Hyperaktivitätsstörungen zu stehen (Nemiary, Shim, Mattox, & Holden, 2012; Reeves, Postolache, & Snitker, 2008; Erhart et al., 2012; Ottova, Erhart, Rajmil, Dettenborn-Betz, & Ravens-Sieberer, 2012).

Fernsehen und die übermäßige Nutzung des Internets wurden in einigen Studien auch mit sozialem Rückzug in Verbindung gebracht, der wiederum zu vermehrten depressiven Symptomen aufgrund fehlender positiver Verstärker führen könnte (Kraut et al., 1998). Der sozialen Komponente des sitzenden/liegenden Verhaltens scheint eine wichtige Rolle zuzukommen. Beispielsweise berichteten Finne und Kollegen (2014) eine positive Assoziation zwischen *Sedentary Behavior* und dem sozialen Wohlbefinden insbesondere bei Jungen. Auch in der Querschnittsstudie (Manuskript 2) war ein hohes Ausmaß an sitzenden/liegenden Verhaltensweisen bei Jungen mit einem höheren Selbstwert verknüpft. Insgesamt scheinen all diese Mechanismen und Variablen eine wichtige Rolle im Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter zu spielen. Hierzu lassen, wie vorhergehend dargestellt, die Ergebnisse der Studien der vorliegenden Dissertation einige Hinweise zu. Welche Mechanismen, wann und unter welchen Umständen tatsächlich wirksam sind, bedarf weiterer Forschungsarbeit.

Außer Frage steht, dass Jugendliche in modernen Gesellschaften zu viel Zeit im Sitzen/Liegen und zu wenig Zeit mit körperlicher Aktivität verbringen. Beide Verhaltensbereiche scheinen sich zu einem gewissen Ausmaß gegenseitig zu bedingen und gegenläufige Effekte auf die psychische Gesundheit zu haben. Auch in Anbetracht erster Studien, die zudem auf kombinierte negative Effekte von einem hohen Ausmaß an *Sedentary Behavior* und einem geringeren Level an moderater bis intensiver körperlicher Aktivität auf die physische (Santos et al., 2014; Keadle et al.,

2014), aber auch die psychische Gesundheit (Cao et al., 2011) hindeuten, scheint ein umfassender Ansatz zur Verbesserung des bewegungsbezogenen Gesundheitsverhaltens notwendig. Die präsentierten Ergebnisse der Interventionsstudie „läuft.“ legen unter anderem nahe, dass der verfolgte universelle und offene Ansatz zu körperlicher Aktivität zwar eine Bewegungsförderung im außerschulischen Bereich bewirken kann, die angenommene Transferwirkung auf das sitzende/liegende Verhalten der Schüler/innen jedoch ausblieb. Daher sollten zukünftige Interventionen zum einen verstärkt auf eine Steigerung der gesamten körperlichen Aktivität, insbesondere auch von geringer Intensität, fokussieren, da diese in starkem inversen Zusammenhang mit *Sedentary Behavior* zu stehen scheint. Zum anderen ist anzunehmen, dass spezifische Interventionskomponenten zur Reduktion des *Sedentary Behavior* erforderlich sind.

Die meisten Kinder und Jugendlichen in modernen Gesellschaften haben freien Zugang zu Fernsehgeräten und Computern und mit steigendem Alter auch eigene Smartphones (Medienpädagogischer Forschungsverbund Südwest, 2014). Nicht nur scheint bildschirmgebundenes *Sedentary Behavior* äußerst attraktiv zu sein, sondern es scheint auch bestimmte Funktionen für Jugendliche zu erfüllen wie beispielsweise Spaß oder Stressbewältigung (Lohaus, Ball, Klein-Hessling, & Wild, 2005). Wichtiges Ziel der Primärprävention sollte daher auch sein, solche Funktionen und Bedürfnisse zu identifizieren und Strategien zu entwickeln, diese in einem körperlich aktiveren Kontext zu erfüllen. In einigen Studien zeigten sich auch positive Zusammenhänge zwischen *Sedentary Behavior* und der psychischen Gesundheit. Wie beispielsweise in der vorliegenden Querschnittsstudie (Manuskript 2) berichtet, waren bildschirmgebundene sitzende/liegende Beschäftigungen positiv mit dem Selbstwert bei Jungen assoziiert, in einer Studie von Finne et al. (2014) mit dem sozialen Wohlbefinden. Zudem weisen einige Studien auf einen nicht-linearen Zusammenhang zwischen Bildschirmzeit und Indikatoren der psychischen Gesundheit hin (Do, Shin, Bautista, & Foo, 2013; Durkin & Barber, 2002; Kim, 2012): Jugendliche, die sich im Mittelfeld bezüglich der Dauer des bildschirmgebundenen *Sedentary Behavior* befanden, zeigten die beste psychische Gesundheit im Vergleich zu Jugendlichen, die Bildschirmmedien gar nicht beziehungsweise eher exzessiv nutzten. Es scheint naheliegend, dass die Nutzung von modernen Medien in einem moderaten Maß wichtig für die soziale Anerkennung und Entwicklung Jugendlicher ist, da diese zum Leben in modernen Gesellschaften dazugehören. Wichtig scheint daher auch die Förderung der Medienkompetenzen, da insbesondere soziale Medien wie Facebook oder

Twitter mit neuen Herausforderungen und Gefahren (z. B. Cybermobbing oder Schutz der Privatsphäre) verbunden sein können (O'Keeffe & Clarke-Pearson, 2011). Aber auch die zusätzlichen Chancen der Mediennutzung sollten hervorgehoben werden, da vor allem über das Internet sehr viele Kinder und Jugendliche auf einem attraktiven Weg erreicht werden können, um gesundheitsbezogene Informationen bereitzustellen und gesundheitsförderliche Interventionen durchzuführen. Auch unter Berücksichtigung einer möglichen umgekehrten Wirkrichtung, das heißt, dass Kinder und Jugendliche mit Beeinträchtigungen der psychischen Gesundheit eher zu sitzenden/liegenden Beschäftigungen neigen, sollten die Potentiale moderner Medien näher beleuchtet werden. Das Internet beispielsweise könnte wichtiger Zugangsweg sein, um Selbsthilfeprogramme beziehungsweise online-basierte Therapien für Kinder und Jugendliche mit psychischen Störungen anzubieten oder die Vernetzung mit andere Betroffenen zu fördern.

4.3 Ausblick und Fazit

Zukünftige Studien zum Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter sind erforderlich, um die bisherigen Befunde zu bestätigen beziehungsweise inkonsistente Ergebnisse besser verstehen zu können. Dabei scheinen folgende Ansätze besonders bereichernd zu sein: (a) Der Einsatz kombinierter Messverfahren, das heißt sowohl objektive als auch ergänzend subjektive, um sowohl die Dauer präzise bestimmen als auch qualitative Aspekte erfassen zu können. (b) Notwendig sind insbesondere längsschnittliche Studien, die eine klare Aussage zur kausalen Wirkrichtung ermöglichen. Auch ein bidirektionaler Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit ist nicht auszuschließen. (c) Die angenommenen Wirkmechanismen und vermittelnden Variablen müssen weiter erforscht und bisherige Befunde repliziert werden. Dabei sollten auch mögliche physiologische Mechanismen bedacht und untersucht werden. (d) Die bisherige teilweise sehr inkonsistente Befundlage deutet auf verschiedene, moderierende Variablen hin, die bisher jedoch kaum benannt werden können und daher näher beleuchtet werden sollten.

In einem zweiten Schritt ist der Transfer dieser grundlegenden Forschung in den praktischen Bereich der Prävention und Gesundheitsförderung von Nöten. Die Reduktion sitzender/liegender Verhaltensweisen sollte ein primäres Präventionsziel im Jugendalter sein, wobei ganzheitliche Ansätze, die auch die Bewegungsförderung im Fokus haben, besonders wünschenswert sind.

Hierfür scheinen spezifische Interventionskomponenten notwendig, die auch die funktionalen Aspekte der Bildschirmzeit im Jugendalter berücksichtigen. Das Verständnis der moderierenden und mediiierenden Variablen im Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit sind vor allem wichtig, wenn es darum geht, mögliche negative Effekte des hochprävalenten sitzenden/liegenden Verhaltens abzumildern. Im Kontext des bildschirmgebundenen *Sedentary Behavior* scheinen insbesondere der richtige Umgang und die kritische Auseinandersetzung mit medial präsentierten Idealen sowie die Stärkung der Kompetenz im Umgang mit sozialen Medien hilfreich. Auf der anderen Seite sollten auch die Möglichkeiten und Chancen des Technologieeinsatzes zur Versorgung Jugendlicher mit Beeinträchtigungen der psychischen Gesundheit näher beleuchtet werden. Auch für die Bewegungsförderung lassen sich moderne Medien vielversprechend einsetzen.

Der rasante gesellschaftliche Wandel der letzten 200 bis 250 Jahre weg von einem aktiven hin zu einem überwiegend sitzenden Lebensstil birgt neue gesundheitliche Risiken, die über einen Abfall der moderaten bis intensiven körperlichen Aktivität hinauszugehen scheinen. Dabei sind nach bisherigem Kenntnisstand, wie in der vorliegenden Dissertation dargelegt, nicht nur Störungen der physischen, sondern auch der psychischen Gesundheit im Kindes- und Jugendalter anzunehmen. Dies ist nicht nur aufgrund des hohen Ausmaßes an *Sedentary Behavior* bedeutsam, sondern insbesondere auch in Anbetracht der Tatsache, dass rund 20% der Kinder und Jugendlichen jedes Jahr von Beeinträchtigungen der psychischen Gesundheit betroffen sind, die häufig bis ins Erwachsenenalter persistieren. Darüber hinaus scheinen früh erlernte Lebensstile ein bedeutsamer Prädiktor für das Gesundheitsverhalten im Erwachsenenalter zu sein. Das heißt, Kinder und Jugendliche, die sehr viel Zeit im Sitzen/Liegen verbringen, werden dieses Verhalten wahrscheinlich ebenso im Erwachsenenalter zeigen und erhöhen damit auch ihr späteres gesundheitliches Risiko. Insgesamt befindet sich die Erforschung des *Sedentary Behavior* jedoch noch im Anfangsstadium. Bisher scheint noch nicht das notwendige Bewusstsein für den richtigen Umgang mit den vielfältigen Alternativen der sitzenden/liegenden Freizeitgestaltung, vor allem bildschirmgebundenen, und der Möglichkeit, heutzutage fast alles im Sitzen/Liegen tun zu können, gefunden zu sein. Hier ist es Aufgabe der Forschung, aber auch des gesundheitlichen Versorgungssektors, einerseits Gefahren des *Sedentary Behavior* klar zu identifizieren und andererseits mögliche Potentiale insbesondere moderner Medien gesundheitsfördernd zu nutzen.

5 ZUSAMMENFASSUNG

5.1 Hintergrund und Zielstellung

Unter dem Begriff *Sedentary Behavior* werden Aktivitäten im Wachzustand zusammengefasst, die in einer liegenden oder sitzenden Position ausgeführt werden und den Energieverbrauch im Vergleich zum Ruheniveau gar nicht beziehungsweise nur geringfügig erhöhen (1 bis 1,5 metabolische Äquivalente). Kinder und Jugendliche in modernen Gesellschaften verbringen im Durchschnitt bis zu acht Stunden pro Tag mit sitzenden/liegenden Beschäftigungen wie Fernsehen, der Nutzung von Computern, sozialen Aktivitäten oder passivem Transport. Das Jugendalter stellt eine hinsichtlich des Bewegungsverhaltens besonders kritische Phase dar, da nicht nur die körperliche Aktivität abnimmt, sondern auch das Ausmaß an *Sedentary Behavior* zunimmt. Beide Verhaltensbereiche hängen zum Teil invers miteinander zusammen, wobei die moderate bis intensive körperliche Aktivität lediglich gering, die gesamte körperliche Aktivität jedoch deutlich stärker mit dem *Sedentary Behavior* assoziiert zu sein scheint.

Immer mehr Studien bringen *Sedentary Behavior* mit gesundheitlichen Beeinträchtigungen in Verbindung. Vor allem im Bereich der physischen Gesundheit scheint dieser Zusammenhang bislang gut belegt: Kinder und Jugendliche, die viel Zeit im Sitzen/Liegen verbringen, vor allem mit Bildschirmmedien, zeigten ein höheres Risiko für Übergewicht, Bluthochdruck, erhöhte Cholesterinwerte sowie eine geringere kardiorespiratorische Fitness. Erste Studien deuten auch auf eine Beeinträchtigung der psychischen Gesundheit hin. Unabhängig von der körperlichen Aktivität stellte sich die Bildschirmzeit beispielsweise als Prädiktor für ein schlechteres physisches Selbstkonzept und eine stärker ausgeprägte depressive Symptomatik heraus. Zudem wurden in einigen Studien additive Effekte eines hohen Ausmaßes an *Sedentary Behavior* und eines geringen Levels an körperlicher Aktivität berichtet.

Zwar ist die Befundlage zur Wirkrichtung bislang noch inkonsistent, dennoch könnten diese Ergebnisse in Anbetracht der hohen Prävalenz des *Sedentary Behavior* bei Kindern und Jugendlichen bedeutsam sein. Nach Schätzungen der Weltgesundheitsorganisation sind weltweit jährlich rund 20% der Jugendlichen von Beeinträchtigungen der psychischen Gesundheit betroffen. Psychische Störungen zählen zu den führenden Ursachen der globalen Krankheitslast von Kindern

und Jugendlichen. Zudem treten erste Anzeichen psychischer Störungen häufig schon im Jugendalter auf und persistieren bis ins Erwachsenenalter. Dennoch, die Untersuchung des Zusammenhangs zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter stellt ein junges und eher inkonsistentes Forschungsfeld dar. Daher soll zunächst in einer systematischen Übersichtsarbeit der aktuelle Forschungsstand zusammengefasst werden, um daraus Schlussfolgerungen für die Praxis und insbesondere zukünftige Forschung zu formulieren.

Viele Studien, die den Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit untersuchten, nutzten in erster Linie einzelne bildschirmgebundene sitzende/liegende Verhaltensweisen oder die gesamte Bildschirmzeit als Indikatoren. Diese stellen jedoch keine adäquate Operationalisierung des *Sedentary Behavior* dar und erschweren die Interpretation, da unklar ist, ob berichtete Assoziationen auf das Sitzen/Liegen an sich oder mediale Effekte wie beispielsweise unangemessene Schönheitsideale zurückzuführen sind. In einer zweiten Studie sollen daher die Assoziationen zwischen bildschirmgebundenem beziehungsweise bildschirmungebundenem *Sedentary Behavior* mit Indikatoren der psychischen Gesundheit getrennt voneinander untersucht werden.

Die Reduktion des *Sedentary Behavior* könnte ein Ansatzpunkt zur Verbesserung der psychischen Gesundheit im Jugendalter sein. Bisherige Interventionen zielten vor allem auf einzelne bildschirmgebundene sitzende/liegende Verhaltensweisen ab und verwendeten in erster Linie kognitive und verhaltensbasierte Strategien. Insgesamt scheinen solche Interventionen zwar wirksam zu sein, jedoch lediglich kleine Effekte hervorzubringen. Problematisch könnte dabei die hohe Attraktivität und leichte Verfügbarkeit des *Sedentary Behavior* sein, während körperliche Aktivität im Gegensatz dazu eher mit Aufwand verbunden und weniger attraktiv zu sein scheint. Zudem könnte auch die Fokussierung auf einzelne sitzende/liegende Verhaltensweisen unzureichend sein, da diese vermutlich eher durch andere sitzende/liegende als durch körperlich aktive Beschäftigungen ersetzt werden. Unter Berücksichtigung dieser Überlegungen sowie der generellen kritischen Entwicklung des bewegungsbezogenen Gesundheitsverhaltens im Jugendalter, welche auch eine deutlich Abnahme der körperlichen Aktivität einschließt, scheinen umfassende Ansätze notwendig zu sein. Als weitere Fragestellung der vorliegenden Dissertation soll dementsprechend ein schulbasierter Interventionsansatz, der auf eine umfassende Steigerung der körper-

lichen Aktivität verschiedener Intensitäten und in unterschiedlichen Kontexten abzielt und damit auch die Reduktion des *Sedentary Behavior* adressiert, evaluiert werden. Die gesamte körperliche Aktivität und das *Sedentary Behavior* sind moderat miteinander assoziiert, das heißt, die Erhöhung einer dieser Verhaltensbereiche zieht wahrscheinlich eine gewisse Reduktion des anderen Verhaltensbereichs mit sich und umgekehrt. Wesentliche Interventionskomponenten sind Schrittzähler und Klassenwettbewerbe. Der Einsatz von Schrittzählern erfolgt in Kombination mit erfolgreichen Strategien der Verhaltensänderung wie Selbst-Monitoring, Zielsetzung und sozialer Unterstützung. Durch die Implementierung von Klassenwettbewerben soll zudem körperliche Aktivität positiv verstärkt werden, um so deren Attraktivität bei den teilnehmenden Jugendlichen zu erhöhen.

5.2 Methodik

Zur Identifizierung relevanter Studien zum Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter erfolgte die systematische Suche in sechs elektronischen Datenbanken (MEDLINE, EMBASE, PsycINFO, PsycARTICLES, CINAHL und SPORTDiscus) sowie der persönlichen Literaturdatenbank der Autoren und den Referenzangaben anderer Übersichtsarbeiten. Wichtige Einschlusskriterien waren: a) eine Altersspanne der Studienstichprobe zwischen 5 und 18 Jahren; b) ein querschnittliches, longitudinales oder experimentelles Studiendesign; c) die Veröffentlichung in Zeitschriften mit Peer-Review-Verfahren; d) Beschreibung des Messverfahrens von *Sedentary Behavior*, welches nicht als Mangel an körperlicher Aktivität definiert ist; e) Angabe des Messverfahrens der psychischen Gesundheit, wobei entsprechend der Definition der Weltgesundheitsorganisation für Gesundheit sowohl psychopathologische Symptome/Syndrome als auch Indikatoren des psychischen Wohlbefindens eingeschlossen wurden; f) publiziert in Deutsch oder Englisch. Als Qualitätsmarker der Primärstudien diente das Studiendesign. Zudem kam eine modifizierte Version der Newcastle-Ottawa Skala zum Einsatz, mit der anhand von acht Items Qualitätsaspekte der externen und internen Validität sowie der Mess- und Auswertungsverfahren der Primärstudien beurteilt werden. Die Datensynthese erfolgte auf Grundlage des Anteils der Primärstudien, die eine bestimmte Assoziation bekräftigten. Das gesamte Vorgehen der systematischen Übersichtsarbeit entsprach den Vorgaben des PRISMA-Statements.

Die Zusammenhänge zwischen bildschirmgebundenem und -ungebundenem *Sedentary Behavior* mit der Depressivität, dem Selbstwert, dem physischen Selbstkonzept sowie der allgemeinen Selbstwirksamkeitserwartung wurden anhand der Baseline-Daten der Evaluationsstudie zur Intervention „läuft.“ untersucht. Dafür wurden die Daten von 1.296 Schüler/innen (47% weiblich) im Alter von 12 bis 17 Jahren (M=13,7 Jahre; SD=0,67 Jahre) mittels Fragebogen erhoben. Zur statistischen Analyse wurden multiple lineare Regressionsanalysen durchgeführt. Die Analysen erfolgten getrennt nach Geschlecht und unter Kontrolle folgender Kovariaten: moderate bis intensive körperliche Aktivität, Alter, Bildung und Gewichtsstatus. Dabei wurde jeder Indikator des psychischen Wohlbefindens auf das gesamte, das bildschirmgebundene sowie das bildschirmungebundene *Sedentary Behavior* regrediert. Zudem wurden mögliche nicht-lineare Zusammenhänge durch visuelle Inspektion sowie die Aufnahme eines quadratischen Terms in die Regressionsanalysen überprüft.

In einer cluster-randomisierten Kontrollgruppenstudie (ISRCTN49482118) wurden die unmittelbaren Effekte der Intervention „läuft.“ auf die körperliche Aktivität, das *Sedentary Behavior* sowie die kardiorespiratorische Fitness evaluiert. Nachdem im Herbst 2013 134 Schulen in Schleswig-Holstein zur Studienteilnahme eingeladen wurden, erklärten sich 29 Schulen mit 61 Klassen und 1.489 Schüler/innen zur Beteiligung bereit. Die Randomisierung erfolgte auf Schulebene in einem Verhältnis von 3:2 (Interventionsgruppe:Kontrollgruppe) und stratifiziert nach Schultyp sowie Anzahl an teilnehmenden Klassen innerhalb der Schule. Insgesamt lagen von 1.162 Schüler/innen (48% weiblich) im Alter von 12 bis 17 Jahren (M=13,7 Jahre; SD=0,67 Jahre) vor Durchführung der Intervention sowie unmittelbar danach Daten vor. Das *Sedentary Behavior* sowie die moderate bis intensive körperliche Aktivität, die sportliche Aktivität in der Freizeit und Alltagsaktivitäten (aktiver Transport und Erledigung von Aufgaben in Haushalt und Garten) wurden mittels Fragebogen erhoben. Die Bestimmung der kardiorespiratorischen Fitness erfolgte mit Hilfe eines progressiven Lauftests. Zur statistischen Analyse der Interventionseffekte wurden lineare Mehrebenen-Regressionsanalysen unter Berücksichtigung der Ebenen Schule, Klasse und Individuum durchgeführt. Hierzu wurde jedes Effektmaß auf die Gruppenvariable, den Messzeitpunkt sowie den Interaktionsterm aus beiden Variablen regrediert.

Hauptkomponenten der 12-wöchigen, schulbasierten Intervention „läuft.“ waren Schrittzähler und Klassenwettbewerbe. Alle Schüler/innen erhielten Schrittzähler und konnten ihre gesammelten Schritte und Erfahrungen auf einer interaktiven Projekt-Homepage dokumentieren. Zudem fanden zwei Klassenwettbewerbe statt: Klassen mit den höchsten Schrittzahlen und den kreativsten Ideen für mehr Bewegung im Schulalltag wurden ausgezeichnet. Vier begleitende Unterrichtseinheiten lieferten Informationen über die Inhalte der Intervention, gaben Anregungen und Reflexionsmöglichkeiten, wie sich mehr Bewegung in den Alltag integrieren lässt und verdeutlichen dies in einer Praxiseinheit. Die Schulleitung und das Lehrerkollegium erhielten Informationsmaterial zu Hintergrund und Inhalt der Intervention sowie Anregungen zur Steigerung der körperlichen Aktivität im Kontext Schule. Auch die Eltern der teilnehmenden Schüler/innen erhielten sowohl Informationsmaterial zur Intervention als auch Anregungen, wie sie ihre Kinder bei der Etablierung eines aktiven Lebensstils unterstützen können.

5.3 Ergebnisse

Insgesamt konnten 91 relevante Studien identifiziert werden. Vier der eingeschlossenen Primärstudien erfassten *Sedentary Behavior* objektiv mit Hilfe von Akzelerometern. In den anderen Studien kamen subjektive Erhebungsinstrumente zum Einsatz, die in erster Linie einzelne Verhaltensweisen oder einen kombinierten Wert für das bildschirmgebundene *Sedentary Behavior* erhoben. In 11 der 91 Primärstudien wurden die Analysen um einen Indikator der körperlichen Aktivität adjustiert. Die Qualität der Primärstudien war insgesamt als moderat einzustufen, wobei die meisten ein querschnittliches Studiendesign nutzten. Die Synthese der Primärstudien zeigte starke Evidenz für einen positiven Zusammenhang zwischen *Sedentary Behavior*, insbesondere bildschirmgebundenem, und Aufmerksamkeits- beziehungsweise Hyperaktivitätsproblemen sowie internalisierten Störungen und einen negativen Zusammenhang mit dem psychischen Wohlbefinden im Kindes- und Jugendalter. Die Zusammenhänge mit depressiven Symptomen, dem Selbstwert sowie mit Angst- und Essstörungen assoziierten Symptomen waren überwiegend inkonsistent. Unter Berücksichtigung der hochqualitativen Studien zeigte sich zudem eine negative Assoziation zwischen der Bildschirmzeit und dem Selbstwert. Einigen Studie untersuchten zudem nicht-lineare Zusammenhänge und konnten eine u-förmige Assoziation zwischen bildschirmgebundenem *Sedentary Behavior* und depressiven Symptomen finden. Zudem konnten in verschiedenen Studien signifikante Zusammenhänge zwischen Indikatoren der psychischen Ge-

sundheit und *Sedentary Behavior* nur für Jungen beziehungsweise nur für Mädchen nachgewiesen werden.

In der vorliegenden Querschnittsstudie zeigten sich Unterschiede in den Zusammenhängen der bildschirmgebunden beziehungsweise bildschirmungebundenen sitzenden/liegenden Verhaltensweisen mit Indikatoren der psychischen Gesundheit. Bei Mädchen war ein höheres Ausmaß an bildschirmgebundenem, nicht aber -ungebundenem *Sedentary Behavior* mit geringeren Werten im Selbstwert ($\beta=-0,090$; $p=0,039$), dem physischen Selbstkonzept ($\beta=-0,125$; $p=0,003$) sowie der allgemeinen Selbstwirksamkeitserwartung ($\beta=-0,134$; $p=0,002$) assoziiert, wobei beides in positivem Zusammenhang mit der Depressivität stand (bildschirmgebunden: $\beta=0,094$; $p=0,032$; bildschirmungebunden: $\beta=0,118$; $p=0,005$). Bei Jungen waren höhere Depressivitätswerte mit einem höheren Ausmaß an bildschirmungebundenem *Sedentary Behavior* verbunden ($\beta=0,084$; $p=0,033$) und mehr Bildschirmzeit mit einem höheren Selbstwert ($\beta=0,105$; $p=0,014$). Zudem stand Letzteres in u-förmigem Zusammenhang mit der allgemeinen Selbstwirksamkeitserwartung ($\gamma=0,094$; $p=0,039$).

Schüler/innen, die an der Intervention „läuft.“ teilnahmen, zeigten im Vergleich zur Kontrollgruppe, die keine Intervention erhielt, einen höheren Anstieg der außerschulischen sportlichen Aktivität (Interaktionsterm: $b=1,09$; $p=0,008$), der Tage mit mindestens 60 Minuten moderater bis intensiver körperlicher Aktivität (Interaktionsterm: $b=-0,29$; $p=0,002$) sowie der täglichen Zeit, in der sie Wege aktiv, das heißt mit dem Fahrrad oder zu Fuß zurücklegten (Interaktionsterm: $b=-20,41$; $p=0,001$). Hinsichtlich des *Sedentary Behavior* ($b=0,06$; $p=0,881$) und der kardiorespiratorischen Fitness (Interaktionsterm: $b=-1,52$; $p=0,065$) konnte jedoch kein Interventionseffekt gefunden werden.

5.4 Diskussion

5.4.1 Synthese und Schlussfolgerungen

Die Ergebnisse der systematischen Übersichtsarbeit zeigen eine eher inkonsistente Befundlage bezüglich des Zusammenhangs zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter. Dennoch ist ein negativer Zusammenhang mit einzelnen Indikatoren anzunehmen. Starke Evidenz lieferte die Synthese der Primärstudien für die Assoziation eines

hohen Ausmaßes an *Sedentary Behavior*, insbesondere bildschirmgebunden, mit mehr Aufmerksamkeits- beziehungsweise Hyperaktivitätsproblemen und internalisierten Störungssymptomen sowie mit weniger psychischem Wohlbefinden. Die Inkonsistenzen hinsichtlich der anderen Indikatoren könnten vor allem auf mögliche Moderatorvariablen, wie beispielsweise das Geschlecht oder die unterschiedliche Operationalisierung des *Sedentary Behavior*, zurückzuführen sein. Die Ergebnisse der wenigen Längsschnitt- und Interventionsstudien deuten darauf hin, dass *Sedentary Behavior* durchaus ursächlich für eine schlechtere psychische Gesundheit sein könnte. Jedoch sind die Befunde hierfür noch nicht eindeutig. Auch ein bidirektionaler Zusammenhang ist nicht auszuschließen.

Insbesondere bildschirmgebundene sitzende/liegende Verhaltensweisen scheinen mit Beeinträchtigungen der psychischen Gesundheit assoziiert zu sein. Dies verdeutlichen nicht nur die Ergebnisse der systematischen Übersichtsarbeiten, sondern auch der präsentierten Querschnittsstudie. Zumindest bei Mädchen war das bildschirmgebundene, nicht jedoch das bildschirmungebundene *Sedentary Behavior* mit einem geringeren Selbstwert, schlechterem physischen Selbstkonzept und einer geringeren allgemeinen Selbstwirksamkeitserwartung assoziiert. Im Gegensatz dazu war sowohl bildschirmgebundenes als auch bildschirmungebundenes *Sedentary Behavior* mit höheren Depressivitätswerten verbunden. Diese Zusammenhänge waren weitestgehend unbeeinflusst vom Ausmaß der moderaten bis intensiven körperlichen Aktivität, was einen weiteren Hinweis dafür liefert, dass *Sedentary Behavior* einen von der körperlichen Aktivität unabhängigen gesundheitlichen Risikofaktor darstellt. Bei Jungen schien das *Sedentary Behavior* bezüglich der erfassten Konstrukte kaum eine Rolle zu spielen. Dies könnte insbesondere mit der deutlich geringeren Prävalenz internalisierter Störungssymptome, wie sie in der vorliegenden Studie erfasst wurden, in Verbindung stehen. Zudem könnten Computer- und Videospiele, deren Nutzung vor allem unter Jungen verbreitet ist, durch die Meisterung steigender Anforderungen und Herausforderungen innerhalb der Spiele, Quellen von Anerkennung und Stolz sein. In einigen Studien konnte außerdem eine positive Assoziation zwischen bildschirmgebundenen sitzenden/liegenden Verhaltensweisen und der Qualität sozialer Beziehungen gefunden werden, die bei Jungen besonders ausgeprägt zu sein scheint.

Die Untersuchung möglicher mediierender Variablen im Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit im Kindes- und Jugendalter steht noch am Anfang. Vermutlich sind aber verschiedene vermittelnde Mechanismen im Zusammenhang zwischen unterschiedlichen Arten des *Sedentary Behavior* und verschiedenen Indikatoren der psychischen Gesundheit von Bedeutung. In der präsentierten Querschnittsstudie waren bei Mädchen sowohl bildschirmgebundene als auch bildschirmungebundene sitzende/liegende Verhaltensweisen mit höheren Depressivitätswerten assoziiert. Dies könnte auf eher generelle, möglicherweise physiologische Mechanismen, wie sie auch im Zusammenhang zwischen der körperlichen Aktivität und der psychischen Gesundheit gefunden wurden, hindeuten. Auch die sogenannte *Ersetzungshypothese* wird diskutiert. Diese vermutet, dass sitzende/liegende Beschäftigungen die Zeit, die andernfalls mit körperlicher Aktivität verbracht würde, ersetzt und damit die positiven Effekte körperlicher Aktivität auf die psychische Gesundheit entfallen beziehungsweise reduziert werden.

Zudem scheinen verschiedene bildschirmspezifische Mechanismen im Zusammenhang mit der psychischen Gesundheit relevant zu sein, wie vor allem auch die Ergebnisse der Querschnittsstudie nahelegen. Hier könnten die vielfältigen Möglichkeiten des sozialen Vergleichs, insbesondere mit häufig unrealistischen medialen Schönheitsidealen eine wichtige Rolle spielen. In verschiedenen Studien wurden Diskrepanzen zwischen dem medialen Idealbild und dem eigenen Körperbild mit einem geringeren Selbstwert und Depressivität in Verbindung gebracht. Bezüglich des in der systematischen Übersichtsarbeit gefundenen Zusammenhangs mit Aufmerksamkeits-/Hyperaktivitätsproblemen wird als mögliche Hypothese diskutiert, dass sich Kinder und Jugendliche, die viel Fernsehen und Videospiele nutzen, an die schnellen Eindruckswechsel gewöhnen und dadurch vermehrt Schwierigkeiten haben, ihre Aufmerksamkeit dem deutlich langsameren „echten Leben“, beispielsweise in der Schule, zu widmen. In einigen Studien wurde bildschirmgebundenes *Sedentary Behavior* mit einer ungesünderen Ernährung sowie Übergewicht in Verbindung gebracht. Diese wiederum scheinen mit mehr depressiven Symptomen, Aufmerksamkeits-/Hyperaktivitätsproblemen und einer geringeren Lebenszufriedenheit assoziiert zu sein.

Insgesamt steht außer Frage, dass Jugendliche in modernen Gesellschaften zu viel Zeit mit sitzenden/liegenden Verhaltensweisen verbringen. Auch das Ausmaß der körperlichen Aktivität ist kritisch zu bewerten. In Anbetracht der gegenläufigen gesundheitlichen Effekte der körperlichen

Aktivität und des *Sedentary Behavior* sowie erster Studienergebnisse, die additive Effekte nahelegen, scheinen umfassende Interventionsansätze besonders wünschenswert. Dabei sollte sowohl eine Erhöhung der körperlichen Aktivität als auch eine Reduktion des *Sedentary Behavior* angestrebt werden. Die schulbasierte Intervention „läuft“, die ebenfalls einen umfassenden Ansatz verfolgte, schien zwar positive Effekte auf die körperliche Aktivität, nicht jedoch auf das *Sedentary Behavior* zu haben. Es ist anzunehmen, dass sich vorrangig die moderate bis intensive körperliche Aktivität erhöhte, die eher gering mit *Sedentary Behavior* assoziiert ist, und nicht die gesamt körperliche Aktivität, die auch geringe Intensitäten umfasst. Zudem scheinen spezifische Interventionskomponenten zur Reduktion des sitzenden/liegenden Verhaltens notwendig, die vor allem auch die Bedeutung des *Sedentary Behavior* als einen von der körperlichen Aktivität unabhängigen gesundheitlichen Risikofaktor hervorheben.

5.4.2 Stärken und Limitationen

Die systematische Übersichtsarbeit liefert einen umfassenden Überblick über die bestehende Literatur zum Zusammenhang zwischen *Sedentary Behavior* und verschiedenen Indikatoren der psychischen Gesundheit im Kindes- und Jugendalter. Dabei ist eine wesentliche Stärke dieser Arbeit das systematische Vorgehen nach dem PRISMA Statement. Problematisch waren vor allem das querschnittliche Studiendesign vieler Primärstudien sowie die häufig unzureichende Erfassung des *Sedentary Behavior* mittels Fragebogen und einzelner bildschirmgebundener Verhaltensweisen.

Bei der präsentierten Querschnittsstudie handelt es sich um eine der ersten Studien, die gezielt Unterschiede in den Zusammenhängen zwischen bildschirmgebundenem und bildschirmungebundenem *Sedentary Behavior* und Indikatoren der psychischen Gesundheit im Jugendalter untersucht. Zudem wurden wichtige Störgrößen, wie die körperliche Aktivität, in den Analysen berücksichtigt. Wesentliche Limitationen stellen die subjektive Erfassung des *Sedentary Behavior* sowie das querschnittliche Studiendesign, welches keine Aussagen zur kausalen Wirkrichtung zulässt, dar.

Als wichtige Stärke der Evaluationsstudie „läuft.“ sind das systematische, im Vorwege protokollierte Vorgehen, die große Stichprobe und die strengen statistischen Analysemethoden zu nennen.

Bezüglich der Intervention selbst ist vor allem der offene und universelle Ansatz zu körperlicher Aktivität positiv hervorzuheben. Einschränkend sind vor allem die subjektiven Erfassungsmethoden der körperlichen Aktivität und des *Sedentary Behavior* zu nennen. Auch der Einsatz spezifischer Interventionskomponenten zur Reduktion des *Sedentary Behavior* scheint notwendig.

5.4.3 Ausblick und Fazit

Die Unterscheidung zwischen bildschirmgebundenem und -ungebundenem *Sedentary Behavior* oder die Erfassung eines breiten Spektrums an sitzenden/liegenden Verhaltensweisen sollte in zukünftigen Studien vorherrschend sein. Besonders bereichernd könnte die Verbindung aus objektiven und subjektiven Messmethoden sein, um die Dauer präzise bestimmen und gleichzeitig auch qualitative Aspekte beurteilen zu können. Des Weiteren sind Längsschnittstudien von Nöten, um Aussagen zur kausalen Wirkrichtung im Zusammenhang zwischen *Sedentary Behavior* und der psychischen Gesundheit treffen zu können. Auch die Untersuchung medierender und moderierender Variablen bedarf weiterer Forschungsarbeit.

Im praktischen Kontext könnten diese grundlegenden Befunde von Bedeutung sein, um mögliche negative Effekte des hochprävalenten *Sedentary Behavior* auf die psychische Gesundheit von Kindern und Jugendlichen zu erkennen und abzumildern. Neben der Förderung der körperlichen Aktivität, sollte ebenso die Reduktion des sitzenden/liegenden Verhaltens primäres Präventionsziel sein. Auch die Stärkung der Kompetenz im Umgang mit Bildschirmmedien scheint wichtig zu sein, da der Zugang zu Fernsehen und Internet sehr leicht und deren Nutzung Teil des Lebens in modernen Gesellschaften ist. Zudem sollten die Möglichkeiten und Chancen des Technologieeinsatzes zur Versorgung Jugendlicher mit Beeinträchtigungen der psychischen Gesundheit beleuchtet werden.

Insgesamt scheint bisher noch nicht das notwendige Bewusstsein für den richtigen Umgang mit den vielfältigen sitzenden/liegenden Freizeitaktivitäten, vor allem bildschirmgebunden, und der Möglichkeit, heutzutage fast alles im Sitzen/Liegen tun zu können, gefunden zu sein. Hier ist es Aufgabe der Forschung, aber auch des gesundheitlichen Versorgungssektors, einerseits Gefahren des *Sedentary Behavior* klar zu identifizieren und andererseits mögliche Potentiale insbesondere moderner Medien gesundheitsfördernd einzusetzen.

6 KURZZUSAMMENFASSUNG IN ENGLISCH (ABSTRACT)

Objective: Adolescence is a critical time period with regard to activity-related health behavior, since on the one hand levels of physical activity considerably decrease and on the other hand there is a remarkable increase of time spent sedentary. Furthermore, both behavioral categories are supposed to be negatively correlated with each other. A growing body of research examined a negative relationship between sedentary behavior and physical health which is independent of physical activity. However, less is known about impairments of mental health. In addition, most studies operationalized sedentary behavior by using only single screen-based activities or the whole screen time. Therefore, a comprehensive overview of the existing literature dealing with the association between sedentary behavior and mental health in childhood and adolescence will be provided. In a second step, the associations between screen-based and non-screen-based sedentary behavior with indicators of mental health will be investigated separately. Finally, a school-based intervention aiming at the enhancement of physical activity and a reduction of sedentary behavior will be evaluated.

Methods: A systematic search of six electronic data bases as well as the personal library of authors and reference lists of existing reviews was conducted to identify relevant primary studies assessing the relationship between sedentary behavior and indicators of mental health in childhood and adolescence.

Differences in the association between screen-based and non-screen-based sedentary behavior and depressed affect, self-esteem, physical self-concept as well as general self-efficacy were examined by analyzing baseline data of the “läuft.” evaluation trial. Data of 1,296 students (age: $M=13.7$, $SD=0.67$; 47% girls) were assessed through self-administered questionnaires.

In a cluster-randomized controlled trial with 1,162 students (age: $M=13.7$, $SD=0.67$; 48% girls) immediate effects of the intervention “läuft.” on students’ physical activity, sedentary behavior and cardiorespiratory fitness were investigated. Main components of the 12-weeks school-based intervention “läuft.” were pedometers and class competitions. Classes with the highest average step counts and the most creative ideas about how to increase physical activity in everyday school life were awarded.

Results: Data synthesis of 91 relevant primary studies provided strong evidence for a positive association between sedentary behavior, especially screen-based, and inattention/hyperactivity problems as well as internalizing problems and a negative relationship with psychological well-being of children and adolescents. The associations with depressive, anxiety and eating disorder symptoms as well as with self-esteem were predominantly inconsistent.

In the cross-sectional study mentioned above, lower scores in self-esteem, physical self-concept as well as general self-efficacy were associated with higher screen-based but not non-screen-based sedentary behavior in girls. Both were associated with higher depressed affect. Among boys higher levels of screen time related to higher self-esteem, while a higher score of depressed affect was associated with more non-screen-based sedentary behavior. In addition, a u-shaped association was found between boys' screen time and general self-efficacy.

Students in the intervention group ("läuft.") showed a higher increase of out-of-school sports activities, of days engaging in a minimum of 60 minutes of moderate to vigorous physical activity as well as of the time per day spent with active commuting compared to students in the control group that received no further intervention. With regard to sedentary behavior and cardiorespiratory fitness no intervention effect was found.

Discussion: The association between sedentary behavior and mental health indicators was rather indeterminate. Nevertheless, a negative relationship with single indicators of mental health was apparent. Future studies should differentiate between screen-based and non-screen-based sedentary behavior or should assess a broad range of sedentary activities. It can be assumed that different mediating mechanisms play a role in the relationship between various sedentary activities and various indicators of mental health. The investigation of mediating and moderating variables should be a major issue of future research. Furthermore, longitudinal studies are needed to draw clear conclusions about causality. There was a positive intervention effect of "läuft." on students' physical activity, but not on their sedentary behavior. Presumably, students in the intervention group enhanced primarily their moderate to vigorous physical activity which showed a rather small correlation with sedentary behavior. Furthermore, tailored intervention components addressing a reduction of sedentary behavior might be necessary.

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ANHANG

Anhang A. Übersicht der Eigenanteile der Autorin an den vorgelegten Manuskripten

Anhang B. Lebenslauf der Autorin

Anhang A. Übersicht der Eigenanteile der Autorin an den vorgelegten Manuskripten

	Manuskript 1	Manuskript 2	Manuskript 3	Manuskript 4
Konzept und Design/ Idee für die Studie	xxx	xxx	x	x
Datenerhebung	xxx	xxx	0	xxx
Datenanalyse	xxx	xxx	0	xxx
Interpretation der Daten	xxx	xxx	0	xxx
Erstfassung des Manuskripts	xxx	xxx	xxx	xxx
Kritische Revision	xx	xx	xx	xx
Verantwortung für die Endversion	xx	xx	xx	xx

Anmerkungen: 0 – nicht zutreffend; x – keine Mitarbeit; xx – gemeinsam mit Koautoren durchgeführt; xxx – hauptverantwortlich und selbstständig durchgeführt

Anhang B. Lebenslauf der Autorin

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Publikationen

Suchert, V., Isensee, B., Sargent, J., Weisser, B., Hanewinkel, R., & läuft. Study Group (2015). Prospective effects of pedometer use and class competitions on physical activity in youth: a cluster-randomized controlled trial. *Preventive Medicine*, 81, 399-404

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Kongressbeiträge

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Poster und Kurzvortrag: „Sedentary Behavior und Indikatoren des psychischen Wohlbefindens im Jugendalter“

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22. dvs-Hochschultag, Mainz
Vortrag „Evaluationsstudie der schulbasierten Intervention ‚läuft.‘ zur Förderung eines aktiven Lebensstils bei Jugendlichen“