

Universität Ulm
Sektion Sport- und Rehabilitationsmedizin
Leiter: Prof. Dr. Dr. h.c. Jürgen M. Steinacker

Abdominale Adipositas bei Grundschulkindern: Determinanten und Erkenntnisse für die Entwicklung geeigneter Präventionsmaßnahmen

Kumulative Dissertation

zur Erlangung des Doktorgrades der Humanbiologie
der Medizinischen Fakultät der Universität Ulm

vorgelegt von
Meike Traub
Ulm

2018

Amtierender Dekan: Prof. Dr. Thomas Wirth

Erstgutachter: Prof. Dr. Dr. h.c. Jürgen M. Steinacker

Zweitgutachter: Prof. Dr. Rainer Muche

Tag der Promotion: 06.07.2018

Inhaltsverzeichnis

Abkürzungsverzeichnis	IV
Abbildungsverzeichnis.....	V
Tabellenverzeichnis.....	VI
1. Einleitung	1
2. Zielsetzung der Arbeit	3
3. Material und Methoden	5
3.1 Anthropometrie.....	5
3.2 Elternfragebögen.....	5
3.3 Statistische Analysen	6
4. Veröffentlichte Publikationen	7
4.1 Correlates of longitudinal changes in the waist to height ratio of primary school children: Implications for prevention.	7
4.2 Skipping breakfast is detrimental for primary school children: cross-sectional analysis of determinants for targeted prevention	9
4.3 Skipping breakfast, overconsumption of soft drinks and screen media: longitudinal analysis of the combined influence on weight development in primary schoolchildren.	11
5. Zusammenfassung und Ausblick	13
5.1 Relevanz von abdominaler Adipositas	13
5.2 Empfehlungen für die Prävention	13
6. Abstract.....	15
7. Literaturverzeichnis.....	17
8. Danksagung.....	21
9. Anhang	22
9.1 Kesztyüs, D, Traub M, Lauer R, Kesztyues T, Steinacker JM. Correlates of longitudinal changes in the waist to height ratio of primary school children: Implications for prevention. Prev Med Reports. 2016; 3:1-6.	22
9.2 Kesztyüs D, Traub M, Lauer R, Kesztyüs T, Steinacker JM. Skipping breakfast is detrimental for primary school children: cross-sectional analysis of determinants for targeted prevention. BMC Public Health. 2017;17(1):258.	29
9.3 Traub M, Lauer R, Kesztyues T, Wartha O, Steinacker JM, Kesztyues D. Skipping breakfast, overconsumption of soft drinks and screen media: longitudinal analysis of the combined influence on weight development in primary schoolchildren. BMC Public Health. 2018; 18:363.	40

Abkürzungsverzeichnis

BMI: Body mass Index

CASMIN classification: Comparative Analysis of Social Mobility in Industrial Nations

DRKS Deutsches Register Klinischer Studien

ISAK: International Standards for Anthropometric Assessment

KiGGs: Kinder- und Jugendgesundheitssurvey

NCD: non-communicable diseases

OR: Odds Ratio

WHO: Weltgesundheitsorganisation

WHtR: Waist to Height Ratio

Abbildungsverzeichnis

Abbildung 1: Zielsetzung der Arbeit.....	4
--	---

Tabellenverzeichnis

Tabelle 1: Eckdaten zu den durchgeführten Untersuchungen der jeweiligen Publikation ... 7

1. Einleitung

Die Gesundheit der Kinder und Jugendlichen steht in vielen Bereichen der Gesellschaft, und nicht ausschließlich im medizinischen Wissenschaftsbereich oder der Public-Health-Forschung, im Blickpunkt der Diskussion. Übergewicht und Adipositas bei Kindern und Jugendlichen haben in den letzten Jahren stark zugenommen und sind eine ernst zu nehmende Herausforderung. Der Kinder- und Jugendgesundheitssurvey (KiGGS) beschreibt, dass 9 % der drei-bis sechsjährigen Kinder übergewichtig und 2,1 % adipös sind. Bei den Sieben- bis Zehnjährigen sind bereits 15,5 % übergewichtig und 5,7 % adipös [1]. Die Zahlen zeigen den drastischen Anstieg der Übergewichts- und Adipositasprävalenz seit den 1980er-Jahren [2]. Übergewicht und Adipositas stellen ein Gesundheitsrisiko bis in das hohe Erwachsenenalter dar. Kardiovaskuläre Erkrankungen, Diabetes oder orthopädische Probleme können die Folge sein. Es wird angenommen, dass Übergewicht und Adipositas aus einem ungesunden Lebensstil hervorgehen und wesentlich zur Entwicklung nicht-übertragbarer Krankheiten (NCD) beitragen [3]. Unumstritten ist, dass im Kindes- und Jugendalter die Weichen für die Entwicklung eines gesunden Lebensstils und ausgewogenen Gewichtsstatus gelegt werden.

Neben dem derzeit wohl bekanntesten Indikator, dem Body Mass Index [(BMI) Verhältnis von Körpergröße zu Gewicht], stellt die Waist to Height Ratio (WHtR), das Taillenumfang-Körperhöhenverhältnis, ein bedeutendes Maß für die Bestimmung von Übergewicht dar. Anhand des Verhältnisses des Bauchumfangs zur Körpergröße kann eine Einteilung in abdominal adipös vs. nicht abdominal adipös erfolgen. Als Grenze für die WHtR haben Ashwell und Hsieh einen Wert von 0,5 definiert [4]. Trotz Hinweisen, dass die Zunahme von kindlichem Übergewicht stagniert [5], ist eine Zunahme von abdominaler Adipositas zu verzeichnen [6]. Es steht außer Diskussion, dass abdominale Adipositas mehr und mehr als die riskanteste Form von Adipositas gesehen wird. Neueste Forschungsergebnisse bestätigen einen Zusammenhang zwischen abdominaler Adipositas und dem vermehrten Auftreten von verschiedenen NCD [7, 3]. Vielfältige und komplex zusammenhängende Gründe werden für die Entstehung von Übergewicht und Adipositas angeführt. Allerdings spielen neben genetischen und physiologischen Aspekten Faktoren des Lebensstils eine bedeutende Rolle bei der Gewichtszunahme. Aus

diesem Grund ist es von enormer Bedeutung, die Gesundheitspotenziale der Kinder zu identifizieren und stärken.

„Komm mit in das gesunde Boot - Grundschule“

Das Programm „Komm mit in das gesunde Boot“ der Baden-Württemberg Stiftung ist ein schulbasiertes Präventionsprogramm zur Förderung eines aktiven Lebensstils für Grundschulkinder. Im Jahr 2009 wurde es durch die Universität Ulm entwickelt, wird seither wissenschaftlich begleitet und in ganz Baden-Württemberg flächendeckend umgesetzt. Die ganzheitliche Förderung der Kinder in ihrer körperlichen, geistigen und emotionalen Entwicklung sowie die Sensibilisierung für einen gesunden Lebensstil sind Ziele des Programms. Kinder der Jahrgangsstufen eins bis vier sowie deren Lehrkräfte an Grund- und Sonderschulen in Baden-Württemberg haben Zugang zu dem Programm. Das Programm umfasst verhaltens- und verhältnispräventive Komponenten und hat folgende Schwerpunkte:

- Förderung der körperlichen Aktivität
- Reduktion des Konsums zuckerhaltiger Getränke
- Reduktion des Konsums von Bildschirmmedien

Für die Ausbreitung des Programms wird ein Multiplikatorensystem eingesetzt. Einzelne Lehrkräfte aus den Stadt- und Landkreisen Baden-Württembergs werden hierzu von einem wissenschaftlichen Team geschult und schulen wiederum weitere Lehrkräfte. In regionalen Fortbildungen stellt das Programm ein Materialpaket an wissenschaftlich entwickelten Materialien für Eltern, Lehrkräfte und Schulkinder zur Verfügung, die sich an den Zielen des Orientierungs- und Bildungsplans anlehnen. Das Besondere am Programm ist die wissenschaftliche Ausrichtung: Im Herbst 2010 und Herbst 2011 fand die Programmevaluation (Baden-Württemberg Studie) statt.

2. Zielsetzung der Arbeit

In der vorliegenden Arbeit werden die Beziehungen zwischen dem Gewichtsstatus (primär abdominaler Adipositas) und beeinflussenden Lebensstilfaktoren bei Grundschulkindern untersucht, wobei die gewonnenen Erkenntnisse für die Entwicklung bzw. Anpassung von zielgerichteten Präventionsmaßnahmen zukünftig genutzt werden können. Dies illustriert Abbildung 1. Aus der Baden-Württemberg Studie des Programms „Komm mit in das gesunde Boot- Grundschule“ wurden dazu folgende Publikationen bearbeitet und veröffentlicht:

1. Kesztyüs, D, Traub M, Lauer R, Kesztyues T, Steinacker JM. Correlates of longitudinal changes in the waist to height ratio of primary school children: Implications for prevention. *Prev Med Reports*. 2016; 3:1-6.
2. Kesztyüs D, Traub M, Lauer R, Kesztyüs T, Steinacker JM. Skipping breakfast is detrimental for primary school children: cross-sectional analysis of determinants for targeted prevention. *BMC Public Health*. 2017;17(1):258.
3. Traub M, Lauer R, Kesztyues T, Wartha O, Steinacker JM, Kesztyues D. Skipping breakfast, overconsumption of soft drinks and screen media: longitudinal analysis of the combined influence on weight development in primary schoolchildren. *BMC Public Health*. 2018; 18:363.

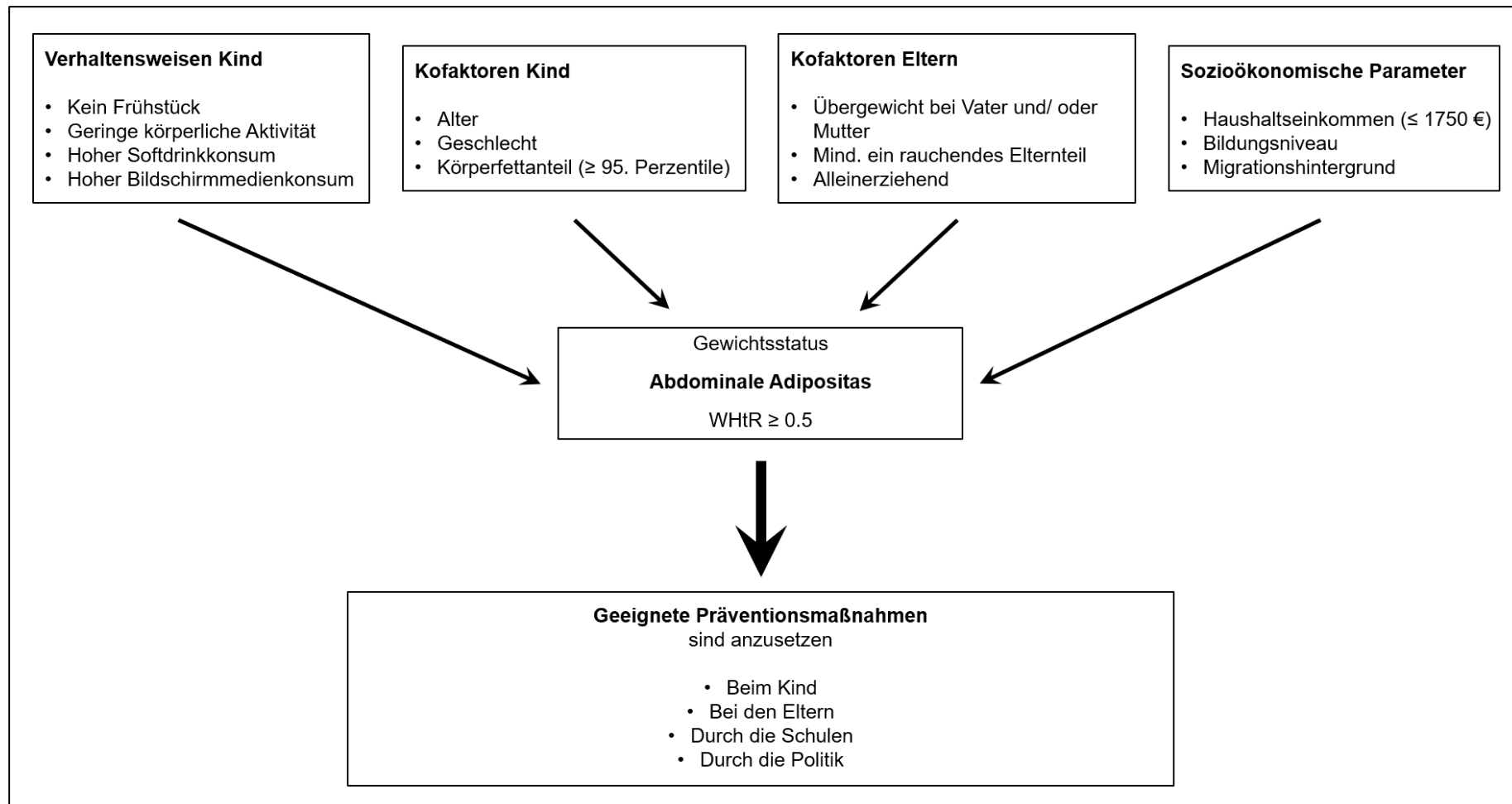


Abbildung 1: Zielsetzung der Arbeit

3. Material und Methoden

Für die Baden-Württemberg Studie wurden die Kinder von einem Messteam aus geschulten Hilfskräften und wissenschaftlichen MitarbeiterInnen des Programms in den Schulen vor Ort untersucht. Weitere Daten wurden mithilfe von Fragebögen schriftlich bei den Eltern erhoben. Die Baden-Württemberg Studie ist eine prospektive, cluster-randomisierte Längsschnittstudie im Warte-Kontrollgruppendesign [8]. Insgesamt wurden fast 2000 Kinder untersucht, für die schriftliche Einverständniserklärungen von Eltern und Lehrkräften vorlagen. Die Studie ist im Deutschen Register Klinischer Studien (DRKS) unter der DRKS-ID DRKS00000494 gespeichert. Das Studienprotokoll wurde von der Ethikkommission der Universität Ulm im Juni 2009 genehmigt (Antragsnummer 126/10).

3.1 *Anthropometrie*

Die anthropometrischen Messungen von Größe, Gewicht und Bauchumfang wurden bei den Kindern in Unterwäsche und ohne Schuhe nach den internationalen Standards für anthropometrische Messungen (ISAK) Standards [9] in den Schulen vor Ort durchgeführt. Die Körpergröße wurde auf 0,1 cm genau mit einem Stadiometer (Seca®, Deutschland) erfasst, das Körpergewicht auf 0,1 kg genau mit einer geeichten und kalibrierten digitalen Waage (Seca®, Deutschland). Der Bauchumfang wurde mit einem Metallmaßband (Lufkin Industries Inc., Texas, USA) in der Mitte zwischen Beckenkamm und unterem Rippenbogen jeweils auf 0,1 cm genau gemessen. Kindliches Übergewicht und Adipositas wurden nach den deutschen alters- und geschlechtsspezifischen Perzentilen bestimmt [10], abdominale Adipositas als WHtR ≥ 0.5 [4]. Der elterliche BMI wurde aus eigenen Angaben im Fragebogen zu Körpergewicht und -größe ermittelt. Übergewicht und Adipositas wurden anhand des BMI nach den Richtlinien der Weltgesundheitsorganisation (WHO) definiert [11]. Die elterliche WHtR wurde aus den selbstberichteten Angaben von Körpergröße und Bauchumfang berechnet.

3.2 *Elternfragebögen*

In den Elternfragebögen machten die Eltern Angaben zu Schwangerschaft und Geburt, sozioökonomischen Rahmendaten sowie zum eigenen Gesundheits- und Lebensstil und dem ihrer Kinder. Für die Auswertung der Daten musste aufgrund der Fülle der erhobenen Parameter eine Auswahl getroffen werden. Diese beschränkte sich hauptsächlich auf Variablen, die im Zusammenhang mit der Ent-

stehung oder dem Vorhandensein von Übergewicht und Adipositas stehen oder vermutet werden. Für die Vermeidung von Verzerrungen der Ergebnisse wurden zusätzlich Kontrollvariablen zur Adjustierung der statistischen Ergebnisse einbezogen. Ein Migrationshintergrund des Kindes wurde angenommen, wenn mindestens ein Elternteil nicht in Deutschland geboren wurde, oder wenn mindestens ein Elternteil mit dem Kind in den ersten fünf Lebensjahren nicht deutsch gesprochen hat. Das Familienbildungsniveau wurde anhand der CASMIN Bildungsklassifikation [12] definiert. Das Haushaltseinkommen wurde an KiGGS angelehnt [13] ermittelt.

3.3 Statistische Analysen

Für alle im Folgenden beschriebenen Publikationen wurden die Unterschiede in den Baseline Charakteristika zwischen Jungen und Mädchen mittels Mann-Whitney-U-Test oder t-Test für stetige Daten bzw. Fisher's exaktem Test für kategoriale Daten bestimmt. Das Signifikanzniveau wurde auf $\alpha = 0.05$ für zweiseitiges Testen festgelegt. Die Gruppenunterschiede wurden mit dem Programm IBM SPSS Statistics 21.0 (SPSS Inc., Chicago, IL, USA) berechnet.

Bei allen Regressionsanalysen wurde aufgrund der Clusterung der Daten in Schulen das Vorliegen eines Schuleffekts geprüft. War dies der Fall, wurde ein linear gemischtes bzw. generalisiertes linear gemischtes Regressionsmodell gerechnet. Die Berechnung erfolgte mit dem Programm R Release 3.2.5 (<http://cran.r-project.org/>). Odds Ratios (OR) wurden mit generalisierten linear gemischten Regressionsmodellen berechnet. Die Bonferroni-Holm Korrektur wurde aufgrund multiplen Testens und der α -Fehler Kumulierung angewendet.

4. Veröffentlichte Publikationen

Für eine bessere Übersicht und auch zur Abgrenzung der einzelnen Arbeiten untereinander dient der Überblick in der Tabelle 1.

Publikation	Studienkohorte	Zielgrößen	Ergebnisse
Correlates of longitudinal changes in the waist to height ratio of primary school children: Implications for prevention.	Komm mit in das gesunde Boot-Grundschule Baseline 2010, Follow-up 2011 (n= 1733)	WHtR	Geringes Haushaltseinkommen, mindestens ein rauchendes Elternteil, Übergewicht bei Vater und/ oder Mutter, kein Frühstück vor der Schule sind signifikante Einflussfaktoren einer Zunahme der WHtR Ältere Kinder sind stärker betroffen als jüngere.
Skipping breakfast is detrimental for primary school children: cross-sectional analysis of determinants for targeted prevention.	Komm mit in das gesunde Boot-Grundschule Baseline 2010 (n= 1943)	Kein Frühstück	Hoher Körperfettanteil (≥ 95 . Perzentile), niedriges Familienbildungsniveau, Migrationshintergrund, alleinerziehendes Elternteil, häufiger Verzehr gesüßter Getränke, hoher Konsum von Bildschirmmedien, geringe körperliche Aktivität sowie Mädchen zu sein korrelieren mit dem Verzicht auf das Frühstück.
Skipping breakfast, overconsumption of soft drinks and screen media: longitudinal analysis of the combined influence on weight development in primary schoolchildren.	Komm mit in das gesunde Boot-Grundschule Baseline 2010, Follow-up 2011 (n= 1733)	WHtR, Gewicht und BMIperzentile, abdominale Adipositas, Übergewicht und Adipositas im Follow-up	Kein Frühstück führt zu Veränderungen in WHtR, Gewicht und BMIperzentilen. Kein Frühstück und Bildschirmmedienkonsum bei Baseline führen zu höheren Odds für abdominale Adipositas und Übergewicht im Follow-up. Kein Zusammenhang zwischen Softdrinkkonsum und Gewichtsentwicklung.

Tabelle 1: Eckdaten zu den durchgeführten Untersuchungen der jeweiligen Publikation

Im Folgenden werden die einzelnen Publikationen im Detail vorgestellt.

4.1 *Correlates of longitudinal changes in the waist to height ratio of primary school children: Implications for prevention.*

Trotz der berichteten Stagnation von kindlichem Übergewicht nach der BMI-Definition [5], ist eine Zunahme bei abdominaler Adipositas zu verzeichnen [6]. Ersteres ist möglicherweise teilweise darauf zurückzuführen, dass der BMI über

ein Viertel der Kinder mit einem sehr hohen Körperfettanteil nicht berücksichtigt [14]. Adipositas-assoziierte Gesundheitsrisiken sind größtenteils mit einer erhöhten intraabdominellen Fettmasse verbunden [15]. Eine WHtR ≥ 0.5 gilt bei Erwachsenen und Kindern als gesundheitsbedenklich [4]. Frühere Studien zeigen, dass abdominale Adipositas bei Kindern beispielsweise mit einer niedrigeren gesundheitsbezogenen Lebensqualität, mehr Krankheitstagen und Arztbesuchen im Vergleich zu den gleichaltrigen Altersgenossen einhergehen [16, 17]. Zahlreiche Studien beschreiben eine Gewichtszunahme im Zusammenhang mit dem BMI. Jedoch sind wenige Faktoren bekannt, die zur Entwicklung von abdominaler Adipositas bei Grundschulkindern beitragen. Ziel der Publikation war es, die longitudinale Entwicklung der WHtR bei Grundschulkindern zu untersuchen sowie modifizierbare Einflussfaktoren für die Prävention zu identifizieren.

Im Zuge der Baden-Württemberg Studie wurden 1733 Kinder im Abstand von einem Jahr untersucht. Es lagen für 1545 Kinder Elternfragebögen vor.

Veränderungen der Körpergröße, des Gewichts und der WHtR zwischen den Zeitpunkten Baseline und Follow-up wurden als Differenzen zwischen den Baseline und Follow-up Werten berechnet. Die berechneten Werte der WHtR wurden für das bessere Verständnis und die Interpretation im Regressionsmodell mit 10^2 multipliziert. Zur Bestimmung der Einflussfaktoren auf die Veränderungen der WHtR wurde eine schrittweise lineare Regressionsanalyse durchgeführt.

Zum Zeitpunkt der Baseline Untersuchung waren die teilnehmenden Grundschul Kinder $7,1 \pm 0,6$ Jahre alt. 50,8 % waren Jungen. Signifikante Unterschiede zwischen den Geschlechtern traten unter anderem in der Anthropometrie auf: Mädchen hatten einen geringeren Bauchumfang, waren kleiner, aber häufiger abdominal adipös als Jungen. Die Mütter der Mädchen rauchten signifikant weniger während der Schwangerschaft. Jungen spielten signifikant häufiger im Freien und waren körperlich aktiver als Mädchen. Mädchen verbrachten weniger Zeit mit Bildschirmmedien und frühstückten seltener als Jungen.

Zwischen den beiden Messzeitpunkten nahm bei beiden Geschlechtern sowohl das Körpergewicht als auch die Körpergröße zu. Die WHtR der Grundschul Kinder nahm minimal ab, im Schnitt zwischen den beiden Messzeitpunkten um -0.0076 ± 0.022 , wobei die Zahl der Kinder mit einer WHtR $\geq 0,5$ zum zweiten Messzeitpunkt deutlich zunahm. Signifikante Einflussfaktoren für eine Zunahme der

WHtR im finalen Regressionsmodell waren fehlendes Frühstück, mindestens ein rauchendes Elternteil, Übergewicht bei Vater und/ oder Mutter ($\text{BMI} > 25 \text{ kg/m}^2$) sowie ein geringes Haushaltseinkommen ($\leq 1750 \text{ €}$). Ältere Kinder waren häufiger betroffen als jüngere.

Die Verringerung der WHtR ist physiologisch gesehen nicht sehr bedeutend und kann vielmehr innerhalb der beiden Messzeitpunkte auf den Wachstumsabschnitt der Kinder zurückführbar sein. Ahrens et al. berichten ähnliche kleine Veränderungen in der WHtR bei Kindern dieser Altersgruppe [18]. Jedoch nahm die Zahl der Kinder mit einem $\text{WHtR} \geq 0,5$ zum zweiten Messzeitpunkt deutlich zu. Die Studie identifizierte Einflussfaktoren, die zur Entwicklung longitudinaler Veränderungen in der WHtR bei Grundschulkindern beitragen. Bei der Entwicklung zielgerichteter Maßnahmen zur Prävention abdominaler Adipositas sollte ein Augenmerk auf diese identifizierten Faktoren gerichtet werden. Die aufgezeigten Einfluss- und Risikofaktoren leisten allerdings nur einen geringen Beitrag zur Erklärung der Veränderungen der WHtR, sodass weitere Forschung notwendig ist.

4.2 Skipping breakfast is detrimental for primary school children: cross-sectional analysis of determinants for targeted prevention

Regelmäßiges Frühstück wird bei Kindern und Jugendlichen mit einem geringeren Risiko für Übergewicht und Adipositas verbunden [19, 20]. Beispielsweise konnten bei schweizerischen Kindern, die regelmäßig frühstücken, bessere motorische Fähigkeiten und weniger Übergewicht identifiziert werden [21]. Außerdem trägt das Frühstück zur kognitiven Leistungsfähigkeit während des Unterrichts bei [22]. In der vorhergehenden Studie von Kesztyüs et al. [23] wurde kein Frühstück als modifizierbarer Faktor für die Entwicklung von abdominaler Adipositas bei Grundschulkindern berichtet. Dieses Ergebnis wird durch die Arbeit von Alexander et al. bei lateinamerikanischen Kindern bestätigt, die aufzeigt, dass abdominale Adipositas mit dem Verzicht auf das Frühstück zusammenhängt [24].

Ziel der vorliegenden Arbeit war die Identifikation von Faktoren, die mit dem Nicht-Frühstücken bei den baden-württembergischen Grundschulkindern zusammenhängen, um gesundheitsfördernde Interventionen für eine ausgewogene Gewichtsentwicklung bei Kindern zu entwickeln.

Am Baseline Messzeitpunkt der Baden-Württemberg Studie nahmen 1934 Grundschul Kinder teil. Da Zweifel bestehen, ob der Grenzwert für abdominale Adipositas

von 0,5 bei Kindern ausreichend sensitiv ist, wurden die von Nambiar et al. vorgeschlagenen Grenzwerte von 0,47 für Mädchen und 0,48 für Jungen in der Studie verwendet [25]. Sie korrelieren mit der 95. Perzentile Körperfett.

Eine generalisierte lineare gemischte Regressionsanalyse wurde zur Bestimmung korrelierender Faktoren für fehlendes Frühstück hinsichtlich der OR und dem 95. Konfidenzintervall für Zielgruppen und Verhaltensweisen (in zwei Submodellen) durchgeführt.

Zum Zeitpunkt der Baseline-Untersuchung waren die Grundschulkinder (n= 1943) $7,1 \pm 0,6$ Jahre alt, davon waren 51,2 % Jungen. Es zeigten sich Unterschiede zwischen den Geschlechtern: Mädchen haben einen signifikant geringeren Bauchumfang, signifikant seltener einen erhöhten Körperfettanteil ($\geq 95.$ Perzentile) und eine signifikant andere Verteilung und Spannweite der WHtR als Jungen. Außerdem spielten sie signifikant weniger im Freien, waren seltener körperlich aktiv und frühstückten seltener als Jungen. Im finalen Regressionsmodell wurden signifikante Zusammenhänge mit fehlendem Frühstück identifiziert. Kinder, die körperlich aktiv sind (≥ 4 Tage/ Woche ≥ 60 Minuten/ Tag) und deren Eltern ein tertiäres Familienbildungsniveau haben, hatten niedrigere Odds für fehlendes Frühstück. Andererseits waren ein Migrationshintergrund, weibliches Geschlecht, ein alleinerziehendes Elternteil, ein hoher Körperfettanteil ($\geq 95.$ Perzentile), häufiger Softdrink (> 1 mal/ Woche) - und Bildschirmmedienkonsum (> 1 Stunde/ Tag) mit höheren Odds für fehlendes Frühstück verbunden. Das Regressionsmodell mit seinen Assoziationen für fehlendes Frühstück wurde in zwei Sub-Modelle für Zielgruppen und veränderbare Verhaltensweisen unterteilt und verlor dabei keine Signifikanzen. Außerdem wurden Sub-Modelle für fehlendes Frühstück für Mädchen und Jungen berechnet. Dabei zeigte sich, dass das Sub-Modell für Mädchen höhere Odds für einen Migrationshintergrund, ein alleinerziehendes Elternteil, einen hohen Körperfettanteil ($\geq 95.$ Perzentile) und häufigen Softdrink- und Bildschirmmedienkonsum zeigte. Im Sub-Modell für Jungen wurden niedrigere Odds für eine hohe körperliche Aktivität und das tertiäre Familienbildungsniveau gefunden.

Die Studie überprüfte Variablen des Gesundheitsverhaltens bei Grundschulkindern, die positiv oder negativ mit fehlendem Frühstück korrelieren. Ein besonderes Augenmerk sollte bei der Entwicklung geeigneter Präventionsmaßnahmen gegen den Frühstücksverzicht auf die identifizierten gesundheitsbezogenen Verhaltens-

weisen bei den vulnerablen Gruppen gerichtet werden. Die identifizierten Unterschiede zwischen Mädchen und Jungen sollten in der geschlechterspezifischen Ausrichtung der Präventionsmaßnahme in der jeweiligen Zielgruppe berücksichtigt werden. Unter Berücksichtigung dieser Erkenntnisse für die Prävention von Frühstücksverzicht kann letztlich abdominaler Adipositas vorgebeugt werden. Zielgerichtete Präventionsmaßnahmen sind daher aus den identifizierten Einflussfaktoren zu entwickeln, sodass die Prävention von Übergewicht durch regelmäßiges Frühstück sowie die Förderung eines gesundheitsbewussten Lebensstils im Vordergrund stehen.

4.3 Skipping breakfast, overconsumption of soft drinks and screen media: longitudinal analysis of the combined influence on weight development in primary schoolchildren.

Neben genetischen und physiologischen Aspekten spielt vor allem der Lebensstil eine bedeutende Rolle bei der Gewichtszunahme von Kindern. Ein hoher Medien- und Softdrinkkonsum [26, 27, 28] sowie fehlendes Frühstück [19] sind bei Kindern und Jugendlichen mit einer Gewichtszunahme und der Entwicklung von Übergewicht und Adipositas verbunden. Das Ziel dieser Studie war die Untersuchung von Softdrink- und Bildschirmmedienkonsum sowie fehlendem Frühstück als Einflussfaktoren der kindlichen Gewichtsentwicklung im Längsschnitt, um gesundheitsfördernde und zielgerichtete Maßnahmen für die Übergewichtsprävention bei Kindern abzuleiten.

Zum Zeitpunkt der Baseline- und Follow-up Untersuchung im Zuge der Baden-Württemberg Studie wurden 1733 Erst- und Zweitklässler untersucht. Der Rücklauf der Elternfragebögen lag bei $n = 1545$. Eine generalisierte linear gemischte Regressionsanalyse wurde für die möglichen Einflüsse von fehlendem Frühstück, Softdrink –und Bildschirmmedienkonsum auf die Prävalenz von abdominaler Adipositas, Übergewicht und Adipositas zum zweiten Messzeitpunkt durchgeführt. Für die Korrelationen von fehlendem Frühstück, hohem Softdrink- und Bildschirmmedienkonsum im Längsschnitt mit Veränderungen in der WHtR, im Gewicht und den BMI Parametern (BMI Perzentile, BMI und BMI z-scores) wurde eine linear gemischte Regressionsanalyse gerechnet. Dafür wurden die berechneten Werte der WHtR für das bessere Verständnis und die Interpretation im Regressionsmodell mit 10^2 multipliziert.

Zum Zeitpunkt der Baseline-Untersuchung waren die Grundschul Kinder ($n=1733$) $7,08 \pm 0,6$ Jahre alt. Davon waren 50,8 % Jungen. Jungen waren signifikant schwerer und weniger abdominal adipös als Mädchen. Allerdings hatten die Jungen einen höheren Bauchumfang. Signifikant mehr Mütter der Mädchen unterließen während der Schwangerschaft das Rauchen als es Mütter von Jungen taten. Jungen spielten signifikant häufiger im Freien, waren körperlich aktiver und verbrachten signifikant mehr Zeit mit Bildschirmmedien als Mädchen. Mädchen frühstückten seltener als Jungen.

Die linear gemischte Regressionsanalyse zeigte, dass Kinder, die nicht frühstücken, signifikant häufiger Veränderungen in der WHtR, im Gewicht und allen BMI Parametern aufzeigten. Ein hoher Softdrink- und Bildschirmmedienkonsum zeigten keine signifikanten Einflüsse auf die Veränderungen in der WHtR, im Gewicht und allen BMI Parametern. In der generalisierten linear gemischten Regressionsanalyse wurden fehlendes Frühstück und ein hoher Bildschirmmedienkonsum mit erhöhten Odds für abdominale Adipositas und Übergewicht im Follow-up identifiziert. Der Softdrinkkonsum zeigte hierbei keine Signifikanzen.

Die Studie betrachtete den Einfluss von fehlendem Frühstück und hohem Softdrink- und Bildschirmmedienkonsum auf die longitudinalen Veränderungen der WHtR, dem Gewicht und BMI Parametern sowie die Prävalenz von abdominaler Adipositas, Übergewicht und Adipositas im Follow-up. Ein besonderes Augenmerk sollte bei der Entwicklung zielgerichteter Präventionsmaßnahmen für einen ausgewogenen Gewichtsstatus bei Grundschulkindern auf Lebensstilfaktoren und die drei untersuchten Verhaltensweisen gelegt werden. Hauptsächlich sollte dabei der Blickpunkt auf den Frühstücksverzicht gerichtet werden, da dieser die einzige durchgehend signifikante Einflussgröße auf die Gewichtsentwicklung bei den baden-württembergischen Grundschulkindern ist.

5. Zusammenfassung und Ausblick

Alle beschriebenen Untersuchungen richten ihren Fokus auf die Zusammenhänge zwischen dem Gewichtsstatus und den beeinflussenden Lebensstilfaktoren bei Grundschulkindern. Es konnte gezeigt werden, dass die Zahl der Kinder mit einer erhöhten WHtR zwischen beiden Messzeitpunkten zunimmt. Sozioökonomische und lebensstilbezogene Einflussfaktoren wurden identifiziert. Kein Frühstück wurde dabei als ein modifizierbarer Faktor für die Entwicklung von abdominaler Adipositas bei Grundschulkindern berichtet, was das Interesse auf die Untersuchung von korrelierenden Faktoren für fehlendes Frühstück lenkte. Dabei wurden Variablen des Gesundheitsverhaltens, die positiv oder negativ mit fehlendem Frühstück korrelieren, untersucht. Die so identifizierten Kofaktoren sowie ein hoher Konsum an Softdrinks und Bildschirmmedien wurden schließlich zusammen mit fehlendem Frühstück longitudinal als mögliche Einflussfaktoren auf die kindliche Gewichtsentwicklung untersucht.

5.1 *Relevanz von abdominaler Adipositas*

Die meisten in der Literatur beschriebenen Studien und Präventionsmaßnahmen wählen als zentrales Maß ihrer Effektivität den BMI oder das Körpergewicht. Der BMI berücksichtigt die allgemeine Körperzusammensetzung im Verhältnis der Körpergröße zum Gewicht und unterscheidet nicht zwischen Übergewicht aufgrund einer erhöhten Fett- oder Muskelmasse, wohingegen die WHtR Informationen zur Fettverteilung bereitstellt. Aktuelle Forschungsergebnisse berichten, dass eine Vielzahl an Personen nach BMI-Definition normal- oder untergewichtig ist, jedoch bei der Betrachtung der WHtR abdominal adipös ist [29, 30]. Für Kinder konnten zunehmende Zahlen abdominaler Adipositas identifiziert werden, wobei Übergewicht und Adipositas definiert nach dem BMI stabil bleiben [6]. Adipositasbedingte Gesundheitsrisiken und NCD sind oftmals auf eine erhöhte WHtR zurückzuführen [7]. Dabei ist die WHtR ein sensiblerer Marker als der BMI zur frühzeitigen Erkennung solcher Gesundheitsrisiken.

5.2 *Empfehlungen für die Prävention*

Die aus allen Untersuchungen gewonnenen Erkenntnisse können zukünftig für die Entwicklung bzw. Anpassung von zielgerichteten Präventionsmaßnahmen genutzt werden. Aus allen Untersuchungsergebnissen kann abgeleitet werden, dass auf

Seiten der Eltern, Schulen und Politik zur Regulation eines ausgewogenen Gewichtsstatus der Kinder beigetragen werden muss.

In den Untersuchungen des „Gesunden Boots“ zeigt sich, dass 30,7 % der Mütter nach eigenen Angaben zum BMI übergewichtig sind und 60,9 % der Väter. 47,3 % der Mütter und 74,5 % der Väter haben die kritische Grenze des WHtR $\geq 0,5$ überschritten. Dies unterstreicht die Empfehlung, Eltern mit in die Prävention einzubeziehen. Eltern dienen als Vorbilder für ihre Kinder, und die Aufklärung über die Vorteile eines gesundheitsbewussten Verhaltens und gesunden Lebensstils sind deswegen unerlässlich. Sowohl die Kinder als auch sie selbst können von diesen Präventionsmaßnahmen profitieren. Weiterhin sollen Schulen mit einbezogen werden, denn durch eine dortige Maßnahmenumsetzung können alle Kinder erreicht werden. Ein vielversprechender Faktor ist dabei die Bereitstellung eines regelmäßigen Frühstücks oder die Förderung des Wassertrinkens durch die Bereitstellung von Wasserspendern bzw. die Beseitigung von Getränkeautomaten, die Softdrinks verkaufen. Schließlich muss die Politik erkennen, dass frühzeitig der Grundstein für einen gesunden Lebensstil gelegt werden muss. Sie sollte ein Augenmerk auf die sozial und ökonomisch benachteiligten identifizierten Zielgruppen richten und diese bei der Umsetzung eines gesunden Lebensstils unterstützen. Demnach sollten Eltern, Schule und Gesellschaft den Grundschulkindern bei der Übergewichtsprävention frühzeitig einen gesunden Lebensstil und ein gesundes Gesundheitsverhalten vermitteln. Zielgerichtete Präventionsmaßnahmen können die Gesundheit der Kinder fördern, indem sie die Eltern und Schulen miteinbeziehen.

Die identifizierten Korrelationen und Determinanten für abdominale Adipositas sowie die gewonnenen Erkenntnisse aus den Untersuchungen können bei der zielgerichteten Anpassung und Weiterentwicklung von Präventionsprogrammen mit dem Ziel der Übergewichtsprävention wie bspw. dem „Gesunden Boot“ genutzt werden. In jeder Hinsicht gilt es gesundheitsfördernde Verhaltensweisen zu fördern und gesunde Lebenswelten zu schaffen. So kann das Risiko des Fortbestehens von kindlichem Übergewicht in das Erwachsenenalter vermieden werden.

6. Abstract

Die Zunahme von Übergewicht und Adipositas bei Kindern und Jugendlichen in den letzten Jahren stellt eine Herausforderung für viele Wissenschafts- und Gesellschaftsbereiche dar. Ein Fünftel der sieben- bis zehnjährigen deutschen Kinder ist übergewichtig oder adipös, was ein Gesundheitsrisiko bis in das Erwachsenenalter bedeutet. Die WHtR ist ein bedeutsamer Indikator für die Bestimmung von abdominaler Adipositas, denn sie stellt ein Gesundheitsrisiko mit einem hohen Einfluss auf nicht-übertragbare Krankheiten dar. Physiologie, Genetik und Lebensstil spielen bei der Entwicklung von Übergewicht und Adipositas eine Rolle. Ziel der Arbeit ist es, die Beziehungen zwischen abdominaler Adipositas und Lebensstilfaktoren bei Grundschulkindern zu identifizieren. Die Erkenntnisse dienen der Entwicklung und Anpassung zielgerichteter Präventionsmaßnahmen.

Dazu wurden bei baden-württembergischen Grundschulkindern anthropometrische Messungen durchgeführt. Ein Elternfragebogen gab Auskunft zu Gesundheitsverhalten, Lebenssituation und sozioökonomischem Hintergrund der Kinder und ihrer Eltern. Bei allen Regressionsanalysen wurde aufgrund der Clusterung der Daten in Schulen das Vorliegen eines Schuleffekts geprüft. Nach Prüfung eines möglichen Schuleffekts durch Clusterung der Daten in Schulen wurde ein linear gemischtes bzw. generalisiertes linear gemischtes Regressionsmodell gerechnet.

Die jeweiligen Regressionsmodelle zeigen, dass sozioökonomische und lebensstilbezogene Faktoren zu longitudinalen Veränderungen in der WHtR führen. Der Frühstücksverzicht wurde dabei als Einflussfaktor für abdominale Adipositas identifiziert. Weiterhin wurden Variablen des Gesundheitsverhaltens, die positiv oder negativ mit fehlendem Frühstück assoziiert sind, untersucht und in zwei Sub-Modelle für Zielgruppen und veränderbare Verhaltensweisen unterteilt. Schließlich wurde der Einfluss eines zu hohen Softdrink- und Bildschirmmedienkonsum sowie fehlendem Frühstück auf die kindliche Gewichtsentwicklung untersucht. Dabei ist der Frühstücksverzicht die durchgehend signifikante Einflussgröße auf die Gewichtsentwicklung bei den Grundschulkindern.

Die gewonnenen Erkenntnisse können der Entwicklung und Anpassung von zielgerichteten Maßnahmen zur Prävention von abdominaler Adipositas dienen. Zukünftige Präventionsmaßnahmen sollten sowohl bei den Kindern als auch auf Sei-

ten der Eltern, Schulen und Politik ansetzen, um zu einem ausgewogenen Gewichtsstatus bei den Grundschulkindern beizutragen.

7. Literaturverzeichnis

1. Schienkiewitz A, Brettschneider AK, Damerow S, Schaffrath Rosario A. Übergewicht und Adipositas im Kindes- und Jugendalter in Deutschland – Querschnittergebnisse aus KiGGS Welle 2 und Trends. *J Heal Monit.* 2018;3(1):16–23.
2. Lobstein T, Baur L, Uauy R, Obesity I. Obesity in children and young people: a crisis in public health. *Obes Rev.* 2004;5 (Suppl 1):4–85.
3. Bloom DE, Cafiero E, Jané-Llopis E, Abrahams-Gessel S, Reddy Bloom L, Fathima S, et al. The Global Economic Burden of Noncommunicable Diseases. 2011.
<http://apps.who.int/medicinedocs/documents/s18806en/s18806en.pdf>.
Letzter Zugriff: 13.04.2018.
4. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *Int J Food Sci Nutr.* 2005;56(5):303–7.
5. Wabitsch M, Moss A, Kromeyer-Hauschild K. Unexpected plateauing of childhood obesity rates in developed countries. *BMC Med.* 2014;12:17.
6. Griffiths C, Gately P, Marchant PR, Cooke CB. A five year longitudinal study investigating the prevalence of childhood obesity: Comparison of BMI and waist circumference. *Public Health.* 2013;127(12):1090–6.
7. Hainer V, Aldhoon-Hainerova I. Obesity paradox does exist. *Diabetes Care.* 2013;36 (Suppl 2):276-81.
8. Dreyhaupt J, Koch B, Wirt T, Schreiber A, Brandstetter S, Kesztyues D, et al. Evaluation of a health promotion program in children: Study protocol and design of the cluster-randomized Baden-Wuerttemberg primary school study. *BMC Public Health.* 2012;12(1):157.
9. Stewart A, Marfell-Jones M, Olds T, De Ridder H. International standards for anthropometric assessment. In: *International Standards for Anthropometric Assessment*. International Society for the Advancement of Kinanthropometry. 2011.

<http://www.ceap.br/material/MAT17032011184632.pdf>. Letzter Zugriff: 13.04.2018.

10. Kromeyer-Hauschild K, Wabitsch M, Kunze D, Geller F, Geiß HC, Hesse V, et al. Perzentile für den Body-mass- Index für das Kindes- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben [Percentiles of bodymass index in children and adolescents evaluated from different regional German studies]. *Monatsschrift Kinderheilkd.* 2001;149:807–18.
11. World Health Organisation. Physical status: the use and interpretation of anthropometry. In: Report of a WHO Expert Committee. WHO Technical Report Series 854. 1995.
http://apps.who.int/iris/bitstream/10665/37003/1/WHO_TRS_854.pdf.
Letzter Zugriff: 13.04.2018.
12. Brauns H, Steinmann S. Educational reform in France, West-Germany and the United Kingdom: updating the CASMIN educational classification. *ZUMA Nachrichten.* 1999;23:7–44.
13. Lange M, Kamtsiuris P, Lange C, Schaffrath Rosario A, Stolzenberg H, Lampert T. Messung soziodemographischer Merkmale im Kinder- und Jugendgesundheitsurvey (KiGGS) und ihre Bedeutung am Beispiel der Einschätzung des allgemeinen Gesundheitszustands. *Bundesgesundheitsblatt - Gesundheitsforsch - Gesundheitsschutz.* 2007;50(5-6):578–89.
14. Javed A, Jumean M, Murad MH, Okorodudu D, Kumar S, Somers VK, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents. *Pediatr Obes.* 2015;10(3):234–44.
15. Balkau B, Deanfield JE, Després J, Bassand J, Fox KAA, Smith SC, et al. International day for the evaluation of abdominal obesity (IDEA): a study of waist circumference, cardiovascular disease, and Diabetes Mellitus in 168 000 primary care patients in 63 countries. *Circulation.* 2007;116(17):1942–51.
16. Kesztyüs D, Wirt T, Kobel S, Schreiber A, Kettner S, Dreyhaupt J, et al. Is

central obesity associated with poorer health and health-related quality of life in primary school children? Cross-sectional results from the Baden-Württemberg Study. *BMC Public Health*. 2013;13:260.

17. Kesztyues D, Schreiber A, Kobel S, Wartha O, Kesztyüs T, Kilian R, et al. Illness and determinants of health-related quality of life in a cross-sectional sample of schoolchildren in different weight categories. *Ger Med Sci*. 2014;12:1–9.
18. Ahrens W, Moreno LA, Mårild S, Molnár D, Siani A, de Henauw S, et al. Metabolic syndrome in young children: definitions and results of the IDEFICS study. *Int J Obes*. 2014;38:4–14.
19. Szajewska H, Ruszczyński M. Systematic review demonstrating that breakfast consumption influences body weight outcomes in children and adolescents in Europe. *Crit Rev Food Sci Nutr*. 2010;50(2):113–9.
20. de la Hunty A, Gibson S, Ashwell M. Does regular breakfast cereal consumption help children and adolescents stay slimmer? A systematic review and meta-analysis. *Obes Facts*. 2013;6(1):70–85.
21. Baldinger N, Krebs A, Müller R, Aeberli I. Swiss children consuming breakfast regularly have better motor functional skills and are less overweight than breakfast skippers. *J Am Coll Nutr*. 2012;31(2):87–93.
22. Donin AS, Nightingale CM, Owen CG, Rudnicka AR, Perkin MR, Jebb S a, et al. Regular breakfast consumption and type 2 diabetes risk markers in 9- to 10-year-old children in the child heart and health study in England (CHASE): a cross-sectional analysis. *PLoS Med*. 2014;11(9):e1001703.
23. Kesztyüs D, Traub M, Lauer R, Kesztyüs T, Steinacker JM. Correlates of longitudinal changes in the waist-to-height ratio of primary school children: Implications for prevention. *Prev Med Reports*. 2016;3:1–6.
24. Alexander KE, Ventura EE, Spruijt-Metz D, Weigensberg MJ, Goran MI, Davis JN. Association of breakfast skipping with visceral fat and insulin indices in overweight Latino youth. *Obesity*. 2010;17(8):1528–33.
25. Nambiar S, Hughes I, Davies PS. Developing waist-to-height ratio cut-offs to define overweight and obesity in children and adolescents. *Public Health*

- Nutr. 2010;13(10):1566–74.
26. Rosiek A, Maciejewska NF, Leksowski K, Rosiek-Kryszewska A, Leksowski L. Effect of television on obesity and excess of weight and consequences of health. *Int J Environ Res Public Health*. 2015;12(8):9408–26.
 27. Bes-Rastrollo M, Sayon-Orea C, Ruiz-Canela M, Martinez-Gonzalez MA. Impact of sugars and sugar taxation on body weight control: A comprehensive literature review. *Obesity*. 2016;24(7):1410–26.
 28. Keller A, Bucher Della Torre S. Sugar-sweetened beverages and obesity among children and adolescents: A review of systematic literature reviews. *Child Obes*. 2015;11(4):338–46.
 29. Coutinho T, Goel K, Corrêa De Sá D, Carter RE, Hodge DO, Kragelund C, et al. Combining body mass index with measures of central obesity in the assessment of mortality in subjects with coronary disease: Role of “normal weight central obesity.” *J Am Coll Cardiol*. 2013;61(5):553–60.
 30. Pischon T, Boeing H, Hoffmann K, Bergmann M, Schulze M, Overvad K, et al. General and abdominal adiposity and risk of death in Europe. *N Engl J Med*. 2008;359(20):2105–20.

8. Danksagung

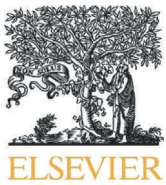
Die Danksagung wurde aus datenschutzrechtlichen Gründen entfernt.

9. Anhang

9.1 Kesztyüs, D, Traub M, Lauer R, Kesztyues T, Steinacker JM. *Correlates of longitudinal changes in the waist to height ratio of primary school children: Implications for prevention. Prev Med Reports. 2016; 3:1-6.*

Open Acces Artikel unter der Lizenz CC BY-NC-ND.

Leistungsbereich	Eigenanteil	Anteil anderer Personen	Spezifizierung des Eigenanteils
Auswertung (Analyse)	20 %	Autorin und Koautoren, 80 %	Datenaufbereitung und Durchführung statistischer Analysen
Manuskript	20 %	Autorin und Koautoren, 80 %	Erstellung von Teilen des Manuskripts, Korrekturarbeiten



Correlates of longitudinal changes in the waist-to-height ratio of primary school children: Implications for prevention

Dorothea Kesztyüs^{a,*}, Meike Traub^a, Romy Lauer^a, Tibor Kesztyüs^b, Jürgen Michael Steinacker^a

^a Ulm University Medical Center, Division of Sport and Rehabilitation Medicine, 89075 Ulm, Germany

^b Ulm University of Applied Sciences, Department of Computer Science, 89081 Ulm, Germany

ARTICLE INFO

Available online xxxx

Keywords (MeSH):

Abdominal obesity

Etiology

Prevention & control

Child

Food habits

ABSTRACT

Objective. To investigate correlates of changes in waist-to-height ratio (WHtR) in primary school children in order to identify modifiable factors usable for prevention.

Methods. Outcome evaluation of a statewide health promotion program in Baden-Württemberg, Germany. Baseline (2010) and follow-up (2011) measurements provided data for the calculation of changes in WHtR. Further information on the health and living conditions of the children were assessed in parental questionnaires. Anthropometric measures were taken in 1733 (50.8% male) first and second grade children (age at baseline 7.1 ± 0.6 years) by staff trained according to ISAK-standards. Stepwise linear regression analysis was applied to identify variables with influence on changes in WHtR.

Results. According to the resulting regression model, changes in WHtR towards an increase were influenced by at least one parent being overweight/obese, at least one parent who smoked, low household income, higher age of the child and the skipping of breakfast. There was no clustering effect in schools observed.

Conclusion. A promising target for prevention of gain in WHtR in primary school children is to ensure the regularity of breakfast. Smoking cessation as well as dietary improvements would not only help children's health but also the health of their parents. The socioeconomic influence on the development of an unhealthy weight status has already been acknowledged and should be extensively targeted by all of society and policy makers.

© 2015 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Abdominal obesity is an underestimated, if not ignored, health risk with a high contribution to several non-communicable diseases (NCD) (Smith & Haslam, 2007; Balkau et al., 2007; Scholze et al., 2007). To define abdominal obesity, a threshold of waist-to-height ratio (WHtR) of 0.5 as recommended by Ashwell and Hsieh (Ashwell & Hsieh, 2005), and confirmed in the systematic review by Browning et al. (Browning et al., 2010) can be used and is also applicable for children. Some researchers have detected rising numbers of abdominal obesity in children (Griffiths et al., 2013; Garnett et al., 2011; Li et al., 2006), while others have reported a leveling off in terms of overweight and obesity defined by body mass index (BMI) (Olds et al., 2011; Rokholm et al., 2010; Wabitsch et al., 2014). The latter may, inter alia, be due to the fact that BMI fails to identify over a quarter of children with excess body fat percentage (Javed et al., 2014). Abdominal obesity is very likely to continue from childhood to adolescence (Chrzanowska et al., 2012).

Children with abdominal obesity experience lower health-related quality of life (HRQoL), are more often sick, and have more visits to a physician than their lean peers (Kesztyüs et al., 2013; Kesztyüs et al., 2014). Each missed day at school implies a hazard to academic achievement and each additional visit to a physician is related to higher health care costs (Kesztyüs et al., 2013).

Obesity and NCDs pose an enormous economic burden on states and national economies. Macroeconomic simulations suggest a cumulative output loss of 75% of global GDP in 2010 for NCDs (Bloom et al., 2011). The direct costs of obesity are estimated to €22.4 billion in Germany in 2020, plus indirect costs of €3.3 billion through losses in productivity (Knoll & Hauner, 2008). In the United States, obesity-attributable medical costs for non-institutionalized adults were estimated at \$190.2 billion or 20.6% of national health expenditures in 2005 (Cawley, 2013). Additionally, childhood obesity was responsible for \$14.1 billion in direct medical costs annually (2002–2005) (Trasande & Chatterjee, 2009). An early implementation of evidence-based health promotion in childhood could help to reverse the trend, but successful and cost-effective programs are rare (Waters et al., 2011; Langford et al., 2014). For abdominal obesity in children, it is crucial to find associated factors that are modifiable and can be targeted by preventive measures.

* Corresponding author at: Division of Sports and Rehabilitation Medicine, Department of Internal Medicine II, Ulm University Medical Centre, Frauensteige 6, Haus 58/33, D-89075 Ulm, Germany. Tel.: +49 731 5004 5374.

E-mail address: dorothea.kesztyues@uni-ulm.de (D. Kesztyüs).

There is a vast amount of literature concerning correlates of weight gain based on BMI, but little is known on the factors leading to abdominal obesity in school children. The importance of this measure especially in children in comparison to BMI is described above. To our knowledge, this is the first study investigating correlates of longitudinal changes in WHtR in primary school children, representing changes in abdominal obesity. The aim is to identify modifiable correlates of changes in WHtR in primary schoolchildren and to consider their usability for primary prevention and health promotion.

Materials and methods

Study design

This research is based on the outcome evaluation of a health promotion program for primary schools in the state of Baden-Württemberg, Germany. The underlying program “Join the healthy boat” provides scientifically developed materials for teachers, pupils and their parents aiming at the development of healthy choices and a healthy lifestyle. To assess the effects, a cluster-randomized controlled trial (“Baden-Württemberg Study”) was set up, with baseline measurements in 2010 and a follow-up after one year in 2011. The ethics committee of Ulm University approved the study protocol and the study is registered on the German Clinical Trials Register (DRKS) under the DRKS-ID: DRKS00000494. Details on the study have already been published elsewhere (Dreyhaupt et al., 2012).

Participants and data

Parents were asked for their written informed consent. Data from direct measurements of children's height, weight and waist circumference (WC) at both baseline and follow-up, were available for 1733 participants, data from parental questionnaires for 1545 (89%) participants. Parents provided information on their own lifestyles, health behavior, and anthropometric data and the lifestyle, health behavior, physical activity patterns and the living environment of their children.

Demographics

The parental level of education was assessed and assigned to the respective level according to the CASMIN classification (Brauns & Steinmann, 1999). Family education level was determined as the highest level of two parents or the level of a single parent who cared for the child. Family education was dichotomized for analysis; elementary and intermediate education levels were taken together in one group, tertiary level in another. The child's migration background was defined as at least one parent being born abroad or at least one parent mainly having spoken a foreign language during the child's first years of life. Household income was graded according to the German KiGGS survey (Lange et al., 2007) and dichotomized for analysis into two groups, the lower group including monthly household incomes of < €1750.

Health and lifestyle characteristics

Parents gave information about maternal smoking during pregnancy, and breastfeeding. Items concerning children's behavior were taken from the validated questionnaires of the German KiGGS survey (Kurth, 2007). They were answered using a 5-point Likert scale: frequency of consuming softdrinks, frequency of playing outside (nearly every day, 3–5 times a week, 1–2 times a week, less than 1 time a week, never), and time spent with screen media (never, about 30 min/day, about 1–2 h/day, about 3–4 h/day, more than 4 h/day). Variables were dichotomized for analyses (soft drinks > 1 time per week, playing outside > 60 min/day, screen media > 1 h/day). Parents stated the frequency of breakfast before school for their children on a 4-point scale,

the results were subsequently dichotomized for analyses (never, rarely vs. often, always). Furthermore, they were asked on how many days a week their children were physically active on a moderate to vigorous level for at least 60 min a day, as recommended by the WHO (World Health Organisation (WHO), 2010). This variable was dichotomized for analyses at the median (physically active ≥ 4 days/week ≥ 60 min/day). Additionally, parents gave information about their own health behavior such as smoking, and were asked to rate their health awareness on a 4-point scale, the results were then dichotomized for analyses (not at all, little vs. strong, very strong).

Anthropometric measurements

Anthropometric measurements of the children were taken by trained staff according to ISAK-standards (Marfell-Jones et al., 2006). The children's height was measured to the nearest 0.1 cm (Stadiometer, Seca®, Germany), and body weight to the nearest 0.1 kg using calibrated and balanced portable digital scales (Seca®, Germany). WC was measured midway between iliac crest and lower costal arch to the nearest 0.1 cm using a flexible metal tape (Lufkin Industries Inc., Texas, USA). The children's BMI was calculated as weight divided by height squared (kg/m^2). Excess weight and obesity were defined at or above the 90th and 97th age- and gender-specific BMI percentiles according to German reference data (Kromeyer-Hauschild et al., 2001). WHtR was calculated as the ratio of WC and height in centimeters, and subsequently participants with a WHtR ≥ 0.5 were categorized as abdominally obese (McCarthy & Ashwell, 2006).

Parental BMI was calculated from self-reported weight and height data in the questionnaires, and categorized as overweight (BMI > 25.0) and obese (BMI > 30.0), according to the international classification of the World Health Organization (WHO) (World Health Organisation (WHO), 1995). Parental WHtR was calculated as the ratio of self-reported WC to height and abdominal obesity defined at and above a WHtR threshold of 0.5 (Vandenbroucke et al., 2007).

Missing data

Common to observational studies is the problem of missing data, which may lead to bias (Ahrens et al., 2014). Baseline differences between records with and without missing variables for the final regression model were examined as described in the statistical analysis section.

Statistical analyses

Differences in baseline characteristics between boys and girls as well as between participants with and without missing values for the final regression model were tested for their statistical significance. The Mann–Whitney–U test or t-test for continuous data and Fisher's exact test for categorical data were applied as appropriate to scale level and distribution of the data. The significance level was set at $\alpha < 0.05$ for two-sided tests. All analyses were carried out using the statistical software packages IBM SPSS Release 21.0 for Windows (SPSSInc, Chicago, IL, USA).

The changes in height, WC and WHtR were calculated as the differences between the values at baseline and the respective values at follow-up. Because of their small size after the decimal point, the resulting numbers of WHtR were then multiplied by 10^2 in order to receive understandable and interpretable values in the regression model. Thus, one unit in dependent variable of the regression model represents 0.01 WHtR. Based on the relevance of content and association with the outcome, all variables listed in Table 1 were included in the stepwise, linear regression analysis as potential explanatory variables. To account for the clustering of data in schools, a possible school-effect was examined in a linear mixed model using the statistical software R Release 3.1.2 for Windows (<http://cran.r-project.org/>).

Table 1
Baseline characteristics of participants in the Baden-Württemberg Study (2010–2011).

	Missing Values	Girls (n = 852)	Boys (n = 881)	Total (n = 1733)
<i>Child characteristics</i>				
Age, years [m (sd)]	0	7.07 (.64)	7.09 (.63)	7.08 (.63)
Migration background, n (%)	244	235 (31.6)	227 (30.5)	462 (31.0)
BMI, [m (sd)]	0	15.99 (2.19)	15.97 (2.08)	15.98 (2.14)
BMIPERC, [m (sd)]	0	48.96 (27.74)	48.15 (27.57)	48.55 (27.65)
Overweight, n (%)	0	82 (9.6)	83 (9.4)	165 (9.5)
Obesity, n (%)	0	30 (3.5)	38 (4.3)	68 (3.9)
Waist circumference, cm [m (sd)]	0	55.15 (5.91)***	55.79 (5.54)	55.48 (5.73)
Height, cm [m (sd)]	0	123.21 (6.30)***	124.39 (6.35)	123.81 (6.35)
WHTR, [m (sd)]	0	0.45 (.04)	0.45 (.04)	0.45 (.04)
Abdominal obesity, n (%)	0	78 (9.2)*	57 (6.5)	135 (7.8)
<i>Parental characteristics</i>				
Single parent, n (%)	218	85 (11.3)	71 (9.3)	156 (10.3)
Tertiary family educational level, n (%)	269	237 (32.6)	238 (32.3)	475 (32.4)
Household income < €1750, n (%)	381	88 (13.1)	83 (12.2)	171 (12.6)
Overweight (mother or father), n (%)	374	492 (73.2)	477 (69.4)	969 (71.3)
Abdominal obesity (mother or father), n (%)	838	382 (85.8)	373 (82.9)	755 (84.4)
Smoking (mother or father), n (%)	222	281 (37.3)	274 (36.2)	555 (36.7)
Health awareness (mother), n (%)	240	437 (58.5)	436 (58.4)	873 (58.5)
Health awareness (father), n (%)	334	299 (43.0)	325 (46.2)	624 (44.6)
<i>Health and lifestyle characteristics</i>				
Maternal smoking during pregnancy, n (%)	196	65 (8.5)*	91 (11.8)	156 (10.1)
Breastfeeding, n (%)	194	651 (85.1)	535 (82.0)	1286 (83.6)
Playing outside > 60 min/day, n (%)	248	462 (62.9)***	558 (74.4)	1020 (68.7)
Physically active ≥ 4 days/week ≥ 60 min/day, n (%)	263	161 (22.1)***	238 (32.1)	399 (27.1)
Screen media > 1 h/day, n (%)	205	86 (11.3)*	119 (15.5)	205 (13.4)
Soft drinks > 1 time per week, n (%)	197	173 (22.6)	191 (24.8)	364 (23.7)
Skipping breakfast, n (%)	195	116 (15.2)**	82 (10.6)	198 (12.9)

m (sd), mean (standard deviation).

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Results

Baseline characteristics

The primary school children who took part in this research had a mean age of 7.1 ± 0.6 years, 50.8% of them were boys. Table 1 shows the baseline characteristics of the participants. Significant differences between boys and girls occurred in anthropometric variables where girls had a slightly lower waist circumference and were less tall. Mothers of girls more often refrained from smoking during pregnancy. Boys more often played outside and reached higher levels of physical activity. Girls spent less time with screen media and more regularly had breakfast.

Changes in anthropometrics

Girls and boys gained height and WC between the baseline and follow-up measurements. For WHTR a slight reduction was observed. Table 2 shows the exact values for the changes in anthropometrics. There were no statistically significant differences between boys and girls.

Table 2
Differences in anthropometric measures between baseline and follow-up in the Baden-Württemberg Study (2010–2011).

	Girls	Boys	Total
Differences in WC, cm [m (sd)]	1.70 (3.03)	1.87 (2.77)	1.78 (2.91)
Differences in height, cm [m (sd)]	6.13 (1.29)	6.18 (1.10)	6.16 (1.20)
Differences in WHTR, [m (sd)]	-.0082 (.023)	-.0071 (.021)	-.0076 (.022)

Note. N = 1733. WC Waist Circumference. WHTR Waist-to-Height Ratio.
m (sd), mean (standard deviation).

To visualize the distribution of WHTR, Fig. 1 shows a histogram of the data at baseline. The distribution is non-normal, with skewness of 2.04 ($SE = .06$) and kurtosis of 8.50 ($SE = .12$), whereas the data of the differences between baseline and follow-up are quasi-normally distributed (not shown). At follow-up, the histogram (Fig. 2) showed a distribution with skewness of 1.53 ($SE = .06$) and kurtosis of 3.95 ($SE = .12$), indicating a change in the shape of the distribution towards normality. However, the proportion of participants at and beyond the WHTR

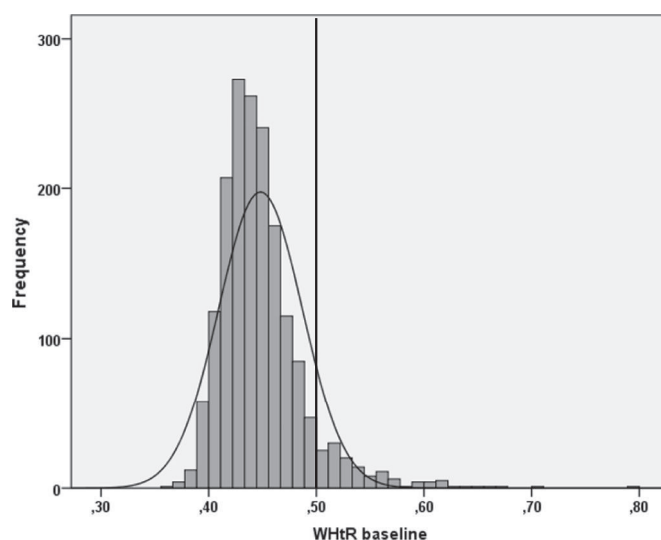


Fig. 1. Histogram of the distribution of WHTR at baseline in the Baden-Württemberg Study (2010–2011). The added vertical line demarcates the threshold of 0.5 that indicates the borderline to abdominal obesity.

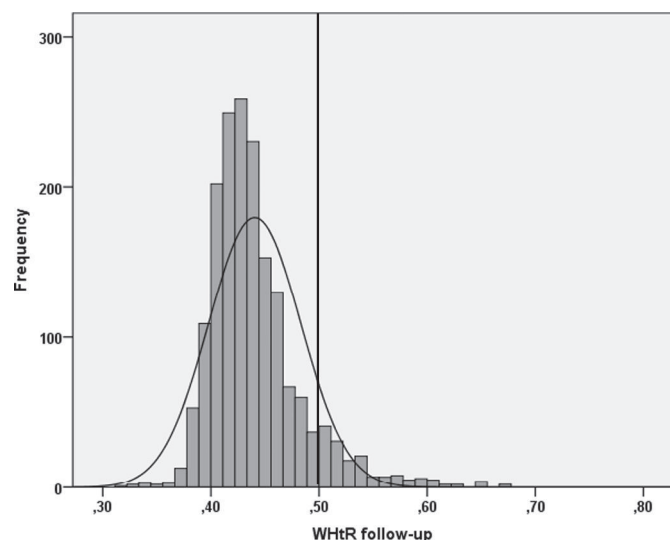


Fig. 2. Histogram of the distribution of WHtR at follow-up in the Baden-Württemberg Study (2010–2011). The added vertical line demarcates the threshold of 0.5 that indicates the borderline to abdominal obesity.

threshold of 0.5 indicating abdominal obesity is visibly higher (9.2% vs 7.8%, $p < 0.001$) at follow-up.

Regression analysis of changes in WHtR

All variables depicted in Table 1 except for anthropometrics of the children were considered with regard to their potential influence on the outcome in the regression analysis. The final model consists of age, skipping breakfast, at least one parent smoking, at least one parent being overweight and household income below €1750. Because of the clustering of data in schools, the intra-class correlation coefficient (ICC) was calculated and revealed that 4.57% of the overall variance is attributable to differences between schools (95% CI [1.73, 7.41]). The underlying health promotion program did not show a significant influence on the metric changes in WHtR. Table 3 shows the results of the linear regression model and the linear mixed regression model, accounting for clustered data in schools.

Missing data

Children with missing data in the independent variables were less likely to have been breastfed, were more likely to have a single parent, were significantly more often overweight, obese and abdominally

Table 3
Non-standardized estimators from a linear regression model (OLS) and fixed effects from a linear mixed regression model (ML) for changes in WHtR in the Baden-Württemberg Study (2010–2011).

	B (OLS)	B (ML)
Intercept	−3.04 (0.70)***	−3.10 (.74)***
Age	.24 (0.10)*	0.25 (.10)*
Skipping breakfast	.39 (.19)*	.36 (.19)†
Smoking (mother or father)	.36 (.13)**	.36 (.13)**
Overweight (mother or father)	.49 (.13)***	0.43 (.13)**
Household income < €1750	.77 (.20)***	0.79 (.20)***
F (5, 1212)	12.88***	
R ²	0.051	
AIC	5256	5258

Note. N = 1212. Estimates and standard errors (in parentheses). Ordinary least squares (OLS). Maximum likelihood (ML). Akaike's information criterion (AIC).

† $p < .10$.

* $p < .05$.

** $p < .010$.

*** $p < .001$.

obese. The average age of mothers at birth was lower and health awareness of fathers was significantly higher. At least one parent was more likely to be abdominally obese. Families more often had a household income of less than €1750 and they had a lower family education level.

Discussion

WHtR of first and second grade primary school children slightly decreased during one year with a mean of minus 0.0076 ± 0.022 between baseline and follow-up. This small overall change is physiologically not very significant and the minus may be mainly due to the natural process of growth of the children. Other researchers report similar small changes of WHtR in this age group (Ahrens et al., 2014). Nonetheless, the proportion of children at and beyond the threshold of WHtR = 0.5, marking the border to abdominal obesity, significantly increased. That makes it crucial to identify modifiable factors with influence on the increase in WHtR to set up targeted preventive measures. The most promising factor in this research is the regularity of breakfast, which can easily be addressed in all kind of interventions at different levels. At an interpersonal level, parents should be informed about the importance of regular breakfast, and at an organizational level, institutions like kindergarten and schools could offer regular breakfast for children. Breakfast frequency and quality may have positive effects for both parents and children (Pereira et al., 2011). Hence, the regularity of breakfast is also an important step in changing dietary patterns for overweight and obese parents, who represent another modifiable factor for changes in children's WHtR. The cessation of smoking as the third modifiable risk factor would have additional far-reaching positive effects on family health besides that of WHtR gain of children. As a further factor of influence, low household income is part of the economic and social disparities that are already well known contributors to the obesity epidemic (Loring & Robertson, 2014). Therefore, a special focus on the socially disadvantaged should always be an important part in developing measures for targeted prevention.

Strengths and limitations

The strength of this research lies within the strict protocol of a cluster-randomized controlled trial and the large number of children and parents that took part, covering the entire state of Baden-Württemberg. The response rate in terms of returned parental questionnaires was 89% at baseline and 87% at follow-up. The anthropometric measurements were of high quality, and taken by trained staff according to ISAK standards (Marfell-Jones et al., 2006). Both measurement periods were short, so that there were no significant differences in the time span between baseline and follow-up measurements per child that would have made it necessary to adjust for in the statistical analyses. Moreover, the possible clustering of data in schools was taken into account in the statistical analyses.

Limitations are mainly due to the observational character of the underlying study. Participation and data themselves may be biased in different ways. Concerning values of self-reported parental weight and smoking, eliminating underreporting and social desirability could result in a more distinct influence of parental excess weight and smoking on increases in children's WHtR. Nonetheless, particularly when keeping in mind underreporting and social desirability responding, the numbers of overweight and abdominal obese parents are alarming. Lastly, health-related behavior of the children like physical activity, screen media use and breakfast habits was not observed but was based on parental information.

Missing values occurred because parents did not return or completely fill in the questionnaires. This may lead to a form of selection bias, but in the best case, only lessen the precision of the study (Morshed et al., 2009). According to the differences in terms of explanatory variables detected in the missing data analysis, children with incomplete data share several critical characteristics, such as higher rates of abdominal obesity

and lower household income. If these participants could have been included into the regression analysis, it would have of course accentuated the results.

Abdominal obesity

There is some discussion on how to define abdominal obesity. Some researchers consider WHtR as an accurate and practicable index to evaluate abdominal obesity, even in children and adolescents (Ashwell & Hsieh, 2005; McCarthy & Ashwell, 2006). In their systematic literature review, de Moraes et al. report that there is no consensus in the literature about the criteria to define abdominal obesity using WC (De Moraes et al., 2011). They report five different anatomical sites used for WC measurement and 18 different cut-off points, which makes it difficult to compare results. To adopt the procedure that is applied to define overweight and obesity according to age and sex specific percentiles for abdominal obesity, a representative reference group is needed. However, the German population in different regions is much too inhomogeneous, with regard to crucial determinants like socioeconomic status or migration background, to rely on such reference values. Therefore, WHtR as a measure of waist circumference adjusted to individual height is less biased than WC percentiles according to a reference group with differing background variables. Fact is, there is little doubt that already in childhood the health risk of abdominal obesity is higher than that of overall obesity (Reinehr & Wunsch, 2010; Rodríguez et al., 2004).

Correlates and risk factors in current research

Correlates of increases in WC and development of abdominal obesity in children is not subject to many investigations. According to results of Garnett et al., it may be assumed that most of the risk factors for general obesity also apply to abdominal obesity (Garnett et al., 2005). Another study by Taveras et al. found out that chronic sleep curtailment from infancy to mid-childhood was associated with total and central adiposity (Taveras et al., 2014). A further study in Malaysian adolescents confirms the present findings on the association of breakfast and abdominal obesity (Nurul-Fadhilah et al., 2013). A review of factors influencing visceral fat accumulation in children and adolescents reports a significant percentage of heritability but also differences due to sex, age and level of development. Moreover the author discusses stress, physical activity and positive energy balance in association with a higher amount of visceral adipose tissue (Suliga, 2009). Maternal smoking during pregnancy was found to be a risk factor for the development of abdominal obesity at later stages of puberty, but not for younger children (Syme et al., 2010) which confirms the present results where smoking during pregnancy was not significantly associated with changes in WHtR. Bradlee and colleagues did not find associations with food group intake and central obesity among children except for the meat intake among boys. For adolescents, they detected inverse associations with the intake of dairy, grains and total fruits and vegetables with central obesity (Bradlee et al., 2010). Kim and Lee report in their review on physical activity and abdominal obesity in youth limited evidence that aerobic types of exercise can alleviate the age-related increase in visceral fat in growing children and adolescents (Kim & Lee, 2009). The present study did not find significant associations between being physically active on at least three days a week or playing outside for a minimum of 60 min each day and changes in WHtR. Developing abdominal obesity is as multicausal as is developing general obesity and in this study we can only add a few pieces to the puzzle, therefore further research should be done to identify the crucial risk factors to initiate targeted preventive measures.

Conclusion

One promising target for the prevention of gain in WHtR in primary school children is to ensure the regularity of breakfast. Smoking

cessation as well as dietary improvements in order to lose weight or to prevent further weight gain would not only help children's health but also the health of their parents. The socioeconomic influence on the development of an unhealthy weight status has already been acknowledged and should be extensively targeted by all of society and policy makers.

Conflict of interest

The authors declare that there are no conflicts of interest.

Acknowledgments

The program “Komm mit in das gesunde Boot – Grundschule” is financed by the Baden-Württemberg Stiftung. The Baden-Württemberg Stiftung had no influence on the content of the manuscript. Thanks to all members of the “Komm mit in das gesunde Boot” research group for their input. Most of all, we thank the teachers, pupils and their parents who participated in the Baden-Württemberg Study. Finally, we thank Sinéad McLaughlin for her language assistance.

References

- Ahrens, W., Moreno, L.A., Mårild, S., Molnár, D., Siani, A., Henauf, S. De, et al., 2014. Metabolic syndrome in young children: definitions and results of the IDEFICS study. *Int. J. Obes.* 38, S4–S14.
- Ashwell, M., Hsieh, S.D., 2005. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *Int. J. Food Sci. Nutr.* 56 (5), 303–307.
- Balkau, B., Deanfield, J.E., Després, J.P., Bassand, J.P., Fox, K.A.A., Smith, S.C., et al., 2007. International day for the evaluation of abdominal obesity (IDEA): a study of waist circumference, cardiovascular disease, and diabetes mellitus in 168 000 primary care patients in 63 countries. *Circulation* 116 (17), 1942–1951.
- Bloom, D.E., Cafiero, E.T., Jané-Llopis, E., Abrahams-Gessel, S., Bloom, L.R., Fathima, S., et al., 2011. The global economic burden of non-communicable diseases. Geneva: World Economic Forum.
- Bradlee, M.L., Singer, M.R., Qureshi, M.M., Moore, L.L., 2010. Food group intake and central obesity among children and adolescents in the Third National Health and Nutrition Examination Survey (NHANES III). *Public Health Nutr.* 13 (6), 797–805.
- Brauns, H., Steinmann, S., 1999. Educational reform in France, West-Germany and the United Kingdom: updating the CASMIN educational classification. *ZUMA Nachr.* 23, 7–44.
- Browning, L.M., Hsieh, S.D., Ashwell, M., 2010. A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0–5 could be a suitable global boundary value. *Nutr. Res. Rev.* 23 (2), 247–269.
- Cawley, J., 2013. NBER Reporter 2013 Number 4: Research Summary The Economics of Obesity [Internet]. pp. 1–5 (Available from: <http://nber.org/reporter/2013number4/cawley.html>).
- Chrzanowska, M., Suder, A., Kruszelnicki, P., 2012. Tracking and risk of abdominal obesity in the adolescence period in children aged 7–15. The cracow longitudinal growth study. *Am. J. Hum. Biol.* 24 (1), 62–67.
- De Moraes, C.F., Fadoni, R.P., Ricardi, L.M., Souza, T.C., Rosaneli, C.F., Nakashima, T., et al., 2011. Prevalence of abdominal obesity in adolescents: a systematic review. *Obes. Rev.* 12 (2), 69–77.
- Dreyhaupt, J., Koch, B., Wirt, T., Schreiber, A., Brandstetter, S., Kesztüis, D., et al., 2012. Evaluation of a health promotion program in children: study protocol and design of the cluster-randomized Baden-Württemberg primary school study [DRKS-ID: DRKS00000494]. *BMC Public Health* 12 (1), 157.
- Garnett, S.P., Cowell, C.T., Baur, L.A., Shrewsbury, V.A., Chan, A., Crawford, D., et al., 2005. Increasing central adiposity: the Nepean longitudinal study of young people aged 7–8 to 12–13 y. *Int. J. Obes.* 29 (11), 1353–1360.
- Garnett, S.P., Baur, L.A., Cowell, C.T., 2011. The prevalence of increased central adiposity in Australian school children 1985 to 2007. *Obes. Rev.* 12 (15), 887–896.
- Griffiths, C., Gately, P., Marchant, P.R., Cooke, C.B., 2013. A five year longitudinal study investigating the prevalence of childhood obesity: comparison of BMI and waist circumference. *Public Health* 127, 1090–1096.
- Javed, A., Jumeau, M., Murad, M.H., Okorodudu, D., Kumar, S., Somers, V.K., et al., 2014. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta-analysis. *Pediatr. Obes.* 1–11.
- Kesztüis, D., Wirt, T., Kobel, S., Schreiber, A., Kettner, S., Dreyhaupt, J., et al., 2013. Is central obesity associated with poorer health and health-related quality of life in primary school children? Cross-sectional results from the Baden-Württemberg Study. *BMC Public Health* 13, 260.
- Kesztüis, D., Schreiber, A., Kobel, S., Wartha, O., Kesztüis, T., Kilian, R., et al., 2014. Illness and determinants of health-related quality of life in a cross-sectional sample of schoolchildren in different weight categories. *Ger. Med. Sci.* 12.
- Kim, Y., Lee, S., 2009. Physical activity and abdominal obesity in youth. *Appl. Physiol. Nutr. Metab.* 34 (4), 571–581.

- Knoll, K.-P., Hauner, H., 2008. Kosten der Adipositas in der Bundesrepublik Deutschland – Eine aktuelle Krankheitskostenstudie. *Adipositas* 2 (4), 204–210.
- Kromeyer-Hauschild, K., Wabitsch, M., Kunze, D., Geller, F., Geiß, H.C., Hesse, V., et al., 2001. Perzentile für den Body-mass-Index für das Kindes- und Jugend- alter unter Heranziehung ver- schiedener deutscher Stichproben [Percentiles of bodymass index in children and adolescents evaluated from different regional German studies]. *Monatsschr. Kinderheilkd.* 149, 807–818.
- Kurth, B.-M., 2007. Der Kinder- und Jugendgesundheitsurvey (KiGGS): Ein Überblick über Planung, Durchführung und Ergebnisse unter Berücksichtigung von Aspekten eines Qualitätsmanagements TL – 50. Bundesgesundheitsbl. Gesundheitsforsch. Gesundheitsschutz 50 (5–6), 533–546.
- Lange, M., Kamtsiuris, P., Lange, C., Rosario, A.S., Stolzenberg, H., Lampert, T., 2007. Messung soziodemographischer Merkmale im Kinder- und Jugendgesundheitsurvey (KiGGS) und ihre Bedeutung am Beispiel der Einschätzung des allgemeinen Gesundheitszustands [Sociodemographic characteristics in the German Health Interview and Examination Survey. Bundesgesundheitsbl. Gesundheitsforsch. Gesundheitsschutz 50 (5–6), 578–589.
- Langford, R., Bonell, C.P., Jones, H.E., Pouliau, T., Murphy, S.M., Waters, E., et al., 2014. The WHO Health Promoting School framework for improving the health and well-being of students and their academic achievement. *Cochrane Database Syst. Rev.* 4 (4), CD008958.
- Li, C., Ford, E.S., Mokdad, A.H., Cook, S., 2006. Recent trends in waist circumference and waist-height ratio among US children and adolescents. *Pediatrics* 118 (5), e1390–e1398.
- Loring, B., Robertson, A., 2014. Obesity and inequities. Guidance for Addressing Inequities in Overweight and Obesity [Internet]. World Health Organisation, Copenhagen, Copenhagen, pp. 1–6 (Available from: http://ec.europa.eu/health/social_determinants/docs/policybrief_obesity_en.pdf).
- Marfell-Jones, M., Olds, T., Stewart, A., Carter, J.E.L. (Eds.), 2006. International Standards for Anthropometric Assessment. North-West University, Potchefstroom, RSA.
- McCarthy, H.D., Ashwell, M., 2006. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message – ‘keep your waist circumference to less than half your height’. *Int. J. Obes.* 30, 988–992.
- Morshed, S., Tornetta, P., Bhandari, M., 2009. Analysis of observational studies: a guide to understanding statistical methods. *J. Bone Joint Surg. Am.* 91 (Suppl. 3), 50–60.
- Nurul-Fadhilah, A., Teo, P.S., Huybrechts, I., Foo, L.H., 2013. Infrequent breakfast consumption is associated with higher body adiposity and abdominal obesity in Malaysian school-aged adolescents. *PLoS One* 8 (3), 1–6.
- Olds, T., Maher, C., Zumin, S., Péneau, S., Lioret, S., Castetbon, K., et al., 2011. Evidence that the prevalence of childhood overweight is plateauing: data from nine countries. *Int. J. Pediatr. Obes.* 6 (June), 342–360.
- Pereira, M.A., Erickson, E., McKee, P., Schrankler, K., Raatz, S.K., Lytle, L.A., et al., 2011. Breakfast frequency and quality may affect glycemia and appetite in adults and children. *J. Nutr.* 141 (1), 163–168.
- Reinehr, T., Wunsch, R., 2010. Relationships between cardiovascular risk profile, ultrasonographic measurement of intra-abdominal adipose tissue, and waist circumference in obese children. *Clin. Nutr.* 29 (1), 24–30.
- Rodríguez, G., Moreno, L.A., Blay, M.G., Blay, V.A., Garagorri, J.M., Sarriá, A., et al., 2004. Body composition in adolescents: measurements and metabolic aspects. *Int. J. Obes. Relat. Metab. Disord.* 28 (Suppl. 3), S54–S58.
- Rokholm, B., Baker, J.L., Sørensen, T.I., 2010. The levelling off of the obesity epidemic since the year 1999 – a review of evidence and perspectives. *Obes. Rev.* 11 (12), 835–846.
- Scholz, J., Lilienthal, W., Bramlage, P., 2007. Kardiometabolische Hochrisikopatienten bei abdominaler Adipositas. *MMW Fortschr. Med.* 149 (S3), 103–110.
- Smith, S.C., Haslam, D., 2007. Abdominal obesity, waist circumference and cardio-metabolic risk: awareness among primary care physicians, the general population and patients at risk—the Shape of the Nations survey. *Curr. Med. Res. Opin.* 23 (1), 29–47.
- Suliga, E., 2009. Visceral adipose tissue in children and adolescents: a review. *Nutr. Res. Rev.* 22 (2), 137–147.
- Syme, C., Abrahamowicz, M., Mahboubi, A., Leonard, G.T., Perron, M., Richer, L., et al., 2010. Prenatal exposure to maternal cigarette smoking and accumulation of intra-abdominal fat during adolescence. *Obesity (Silver Spring)* 18 (5), 1021–1025.
- Taveras, E.M., Gillman, M.W., Peña, M.-M., Redline, S., Rifas-Shiman, S.L., 2014. Chronic sleep curtailment and adiposity. *Pediatrics* 133 (6), 1013–1022.
- Trasande, L., Chatterjee, S., 2009. The impact of obesity on health service utilization and costs in childhood. *Obes (Silver Spring)* 17 (9), 1749–1754.
- Vandenbroucke, J.P., von Elm, E., Altman, D.G., Gøtzsche, P.C., Mulrow, C.D., Pocock, S.J., et al., 2007. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. *PLoS Med.* 4 (10), 1628–1654.
- Wabitsch, M., Moss, A., Kromeyer-Hauschild, K., 2014. Unexpected plateauing of childhood obesity rates in developed countries. *BMC Med.* 12, 17.
- Waters, E., de Silva-Sanigorski, A., Hall, B.J., Brown, T., Campbell, K.J., Gao, Y., et al., 2011. Interventions for preventing obesity in children. *Cochrane Database Syst. Rev.* (12), 1–212.
- World Health Organisation (WHO), 1995. Physical status: the use and interpretation of anthropometry. World Health Organization technical report series. Report of a WHO Expert Committee, p. 329.
- World Health Organisation (WHO), 2010. Global recommendations on physical activity for health. Geneva World Health Organ. 60.

9.2 Kesztyüs D, Traub M, Lauer R, Kesztyüs T, Steinacker JM. *Skipping breakfast is detrimental for primary school children: cross-sectional analysis of determinants for targeted prevention. BMC Public Health. 2017;17(1):258.*

Open Access Artikel

Leistungsbereich	Eigenanteil	Anteil anderer Personen	Spezifizierung des Eigenanteils
Auswertung (Analyse)	40 %	Koautoren, 60 %	Durchführung statistischer Analysen
Manuskript	50 %	Koautoren, 50 %	Erstellung von Teilen des Manuskripts

RESEARCH ARTICLE

Open Access



Skipping breakfast is detrimental for primary school children: cross-sectional analysis of determinants for targeted prevention

Dorothea Keszytüs^{1,2*} , Meike Traub^{1†}, Romy Lauer¹, Tibor Keszytüs³ and Jürgen Michael Steinacker¹

Abstract

Background: Skipping breakfast was found to be associated with abdominal obesity in primary school children. The aim of this research was to examine factors associated with skipping breakfast in primary school children in order to develop targeted preventive measures.

Methods: Baseline data assessment (2010) of a cluster-randomized controlled trial for the evaluation of a school-based health promotion program in primary school children in the state of Baden-Württemberg, Germany. Anthropometric measures of 1,943 primary school children aged 7.1 ± 0.6 years (51.2% boys) were conducted according to ISAK-standards (International Standard for Anthropometric Assessment) by trained staff. Further information on the health and living conditions of the children and their parents were assessed in parental questionnaires. Generalized linear mixed regression analysis was calculated to define correlates for skipping breakfast in terms of odds ratios (OR) and 95% confidence intervals (CI).

Results: According to the final regression models, significant correlates of skipping breakfast can be divided into modifiable behavioral components (high consumption of soft drinks (OR 2.49, 95% CI 1.81; 3.43), screen media (OR 2.48, 95% CI 1.77; 3.46) and high levels of physical activity (OR 0.64, 95% CI 0.44; 0.93)) on the one hand, and more or less static socio-economic factors (migration background (OR 2.81, 95% CI 2.02; 3.91), single parenting (OR 2.13, 95% CI 1.34; 3.40), and high family education level (OR 0.42, 95% CI 0.28; 0.64)) on the other hand, and finally individual factors (female gender (OR 1.43, 95% CI 1.03; 1.99) and having a percentage of body fat at or above the 95th percentile (OR 1.47, 95% CI 1.00; 2.17)).

Conclusion: Targeted prevention should aim at health-related behaviors accompanying the habit of skipping breakfast. Focusing on vulnerable groups, characterized by not so easily modifiable socio-economic as well as individual factors, may improve results. Interventions should synergistically promote children's health and involve their parents in order to be successful. To reach all children and to avoid skipping breakfast, schools should offer regular breakfast at the start of a school day. Policy makers should support healthy eating habits at all times.

Keywords: Child, Food habits, Breakfast, Health promotion, Abdominal obesity, etiology, prevention & control

* Correspondence: dorothea.keszytues@uni-ulm.de

†Equal contributors

¹Division of Sport and Rehabilitation Medicine, Ulm University Medical Center, 89075 Ulm, Germany

²Institute of General Medicine, Ulm University, Helmholtzstraße 20, D-89081 Ulm, Germany

Full list of author information is available at the end of the article



© The Author(s). 2017 **Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated.

Background

There is considerable evidence from systematic reviews for children and adolescents that eating breakfast is associated with a reduced risk of becoming overweight or obese and a reduction in body mass index (BMI) [1, 2]. For example, Swiss children regularly consuming breakfast showed better motor functional skills and were less overweight [3]. For schoolchildren, breakfast plays a positive role in maintaining cognitive function during the morning [4]. Furthermore, English children who regularly consumed breakfast had a more favorable type 2 diabetes risk profile [5] and Greek schoolchildren showed an inverse association of breakfast consumption with HOMA-IR (homeostasis model assessment of insulin resistance index) [6]. In obese children and adolescents, skipping breakfast is correlated with higher levels of blood glucose, triglycerides and very low density lipoprotein cholesterol [7]. Finally, in Canadian children and adolescents, breakfast consumption is positively associated with nutrient adequacy [8].

In a recent study, we identified skipping breakfast as one of the modifiable influencing factors for developing abdominal obesity in primary schoolchildren [9]. This finding is supported by a study of Alexander and colleagues who were able to demonstrate that higher visceral adiposity was associated with skipping breakfast in overweight Latino youth [10]. Abdominal obesity is more and more recognized as the most risky kind of obesity, as it is strongly associated with the majority of non-communicable diseases (NCD), the world's number one killer [11, 12]. Furthermore, a remarkable number of persons who are normal weight according to BMI definition, are abdominally obese and e.g. for subjects with coronary artery disease, those who are normal weight but abdominally obese carry the highest risk of mortality [13]. Concerning children, a meta-analysis revealed that BMI fails to identify excess adiposity in over a quarter of the affected children [14]. A longitudinal study comparing BMI and waist circumference in children concludes "Children appear to be getting fatter and the additional adiposity is being stored centrally which is not detected by BMI" [15]. Those children with abdominal obesity already have a lower health related quality of life, more days of absence at school and more visits to a physician [16].

According to the literature, the frequency of breakfast intake decreases with age in children and adolescents [1, 8, 17]. Systematic reviews report associations of skipping breakfast in youth with lower socioeconomic status, lack of physical activity, frequent use of screen media, higher energy intake, unhealthy eating habits and other unhealthy lifestyle factors such as smoking and alcohol use [1, 17]. All in all, girls were more likely to skip breakfast than boys [1, 17].

Our study was embedded in the outcome evaluation of the health promotion program "Join the Healthy Boat". This program includes health promotion in the curriculum of grades one to four at primary school and combines behavioral and environmental components. Children are empowered to make healthy choices in terms of physical activity, consumption of sugar sweetened beverages, and use of screen media. The aim of the present study is to look at factors that are associated with skipping breakfast in schoolboys and -girls in order to improve preventive and health promoting measures and to help respective multicomponent interventions to reach their goal of promoting healthy weight in children.

Methods

The health promotion program "Join the Healthy Boat" was based on the successful "URMEL ICE" project (Ulm Research on Metabolism, Exercise and Lifestyle Intervention in Children), to the author's knowledge the only school-based prevention program in Germany with proven cost-effectiveness [18].

Study design

The present study was embedded in the baseline-measurements of the outcome evaluation of the school-based health promotion program "Join the Healthy Boat" in the state of Baden-Württemberg, Germany, in the year 2010. The "Baden-Württemberg Study" followed a cluster-randomized design with a waitlist control group. A more detailed description of the study can be found elsewhere [19].

Participants and data

All children in classes of teachers who agreed to participate in the outcome evaluation were eligible (3,159 pupils). Parents of 1,968 first and second graders in 84 schools (5.4 – 9.9 years old), 62% of all eligible children, gave their consent for participation in 2010. Response rate for parental questionnaires was 87% at baseline. Data from direct measurements at schools or from parental questionnaires were available for 1,943 children at baseline. Parents gave information on their health behavior and their socioeconomic background, as well as on the health and lifestyle characteristics of their children.

Demographics

The parental education level was assessed and determined according to the CASMIN (Comparative Analysis of Social Mobility in Industrial Nations) educational classification [20]. CASMIN classifies tertiary level as higher educational levels (e.g. academically-oriented university education), while secondary level includes a range from intermediate vocational qualification to full maturity

certificates (equals 12–13 years of school in Germany), and primary level comprises inadequately completed general education to basic vocational qualification. Family education level was defined as the highest level of two parents or the level of a single parent who mainly cares for the child. For analyses, family education level was dichotomized into tertiary versus intermediate and elementary level. Household income was assessed in several categories according to the German KiGGS survey (German Health Interview and Examination Survey for Children and Adolescents) [21] and dichotomized for analyses at a threshold of €1,750. A migration background was assumed if at least one parent was born abroad or at least one parent had mainly spoken a foreign language during the child's first years of life.

Health and lifestyle characteristics

Questions about children's behavior were taken from the validated questionnaires of the German KiGGS survey [22]. Answers were offered on a 5-point Likert scale for frequency of consuming soft drinks, frequency of playing outside (nearly every day, 3–5 times a week, 1–2 times a week, less than 1 time a week, never), and time spent with screen media (never, about 30 min/day, about 1–2 h/day, about 3–4 h/day, more than 4 h/day). Variables were dichotomized for analyses (soft drinks > 1/week, playing outside > 60 min/day, screen media > 1 h/day). Information on the frequency of participation in club sports were retrieved in an open question and results were dichotomized for analyses (> 1/week). Parents gave information on the frequency of breakfast before school for their children on a 4-point scale, the results were subsequently dichotomized for analyses (never, rarely vs. often, always). Furthermore, parents stated how many days a week their children were physically active on a moderate to vigorous level (starting to sweat and/or get out of breath) for at least 60 min a day, as recommended by the World Health Organization (WHO) [23]. Results were dichotomized for analyses at the median (physically active $\geq$ 4 days/week $\geq$ 60 min/day). Lastly, parents were asked whether they were smokers, and they rated their health awareness on a 4-point scale, the latter variable being then dichotomized for analyses (not at all, little vs. strong, very strong).

Anthropometric measurements

Trained staff conducted the anthropometric measurements of the children according to ISAK-standards [24]. The children's height was measured to the nearest 0.1 cm (Stadiometer, Seca®, Germany), and body weight to the nearest 0.1 kg using calibrated and balanced portable digital scales (Seca®, Germany). Waist circumference (WC) was measured midway between iliac crest and

lower costal arch to the nearest 0.1 cm using a flexible metal tape (Lufkin Industries Inc., Texas, USA). The children's BMI was calculated as weight divided by height squared [kg/m^2]. Excess weight and obesity were defined at or above the 90th and 97th age- and gender-specific BMI percentiles according to German reference data [25]. Waist-to-height ratio (WHtR) was calculated as the ratio of WC and height in centimeters, participants with a WHtR $\geq$ 0.5 were then categorized as abdominally obese [26]. Because there was some doubt the WHtR threshold of 0.5 was sensitive enough, a lower threshold (0.47 for girls and 0.48 for boys) as proposed by Nambiar et al. [27], correlating with the 95th percentile for %body fat, was added.

Parental BMI was calculated with self-reported weight and height data from the questionnaires, and categorized as overweight (BMI $\geq$ 25.0) and obese (BMI $\geq$ 30.0), according to the international classification of the WHO [28]. Parental WHtR was calculated as self-reported WC divided by height in centimeters and abdominal obesity was defined as WHtR $\geq$ 0.5 [29].

Missing data

Missing data are a frequently occurring problem in observational studies, possibly leading to biased results [30]. Therefore, potential significant baseline differences between cases with and without missing values for the full regression model were examined.

Statistical analysis

Differences between boys and girls, as well as between participants with and without missing values, were tested for their statistical significance. Depending on scale level and distribution of the data, the Mann–Whitney-*U* test or *t*-test for continuous data and Fisher's exact test for categorical data were applied. The significance level was set at $\alpha = 0.05$ for two-sided tests. These analyses were carried out using the statistical software packages IBM SPSS Release 21.0 for Windows (SPSSInc, Chicago, IL, USA).

To identify a possible clustering effect of data in schools, the intraclass correlation coefficient ($\text{ICC}_{\text{Logit}}$) for a generalized linear mixed model with binary outcome was calculated according to Eldridge et al. [31]. Depending on the magnitude of the $\text{ICC}_{\text{Logit}}$, the appropriate regression analysis, a logistic or a generalized linear mixed model, was conducted subsequently, considering the variables described above. A closer examination of decisive factors for target groups and target behaviors was realized in two sub-models. These analyses were performed with the statistical software R Release 3.2.5 for Windows (<http://cran.r-project.org/>).

Results

Baseline characteristics

Primary school children who took part in this research had a mean age of 7.1 ± 0.6 years, 51.2% of them were boys. Table 1 shows the baseline characteristics of the participants. Significant differences between boys and girls occurred in anthropometric variables where boys had a slightly higher waist circumference but were less frequently at or above the 95th percentile for %body fat. They also had a different distribution of WHtR with a lower variance and range than girls. Boys more often played outside and reached higher levels of physical activity. Girls more often skipped breakfast than boys.

All variables shown in Table 1 were considered for their potential association with the outcome variable in the regression analyses.

Regression analysis for correlates of skipping breakfast

Unadjusted, crude odds ratios (OR) for skipping breakfast for all variables in the subsequent generalized linear mixed regression models are illustrated in Table 2.

In the bivariate analysis, female gender, migration background, variables of overweight and obesity, single parenthood, lower household income, parental overweight and obesity, parental smoking, one or more soft drinks per week, and screen media use exceeding 1 hour per day had higher odds for skipping breakfast. On the other hand, tertiary family education level, parental health awareness, playing outside more than 60 min per day, and physical activity of more than 60 minutes on 4 days and more per week showed lower odds for skipping breakfast. The ICC_{Logit} of skipping breakfast was 0.045, indicating that 4.5% of the total variance is due to clustering of data in schools. This would lead to differences in the ORs

Table 1 Baseline characteristics of participants in the Baden-Württemberg Study (2010)

	Missing Values	Boys (<i>n</i> = 995)	Girls (<i>n</i> = 948)	Total (<i>n</i> = 1,943)
Child characteristics				
Age, years [m (sd)]		7.09 (0.64)	7.06 (0.63)	7.08 (0.64)
Migration background, <i>n</i> (%)	297	255 (30.9)	270 (32.9)	525 (31.9)
BMIPERC, [m (sd)]	50	48.78 (27.87)	49.14 (27.92)	48.96 (27.89)
Overweight, <i>n</i> (%)	50	54 (5.6)	54 (5.9)	108 (5.7)
Obesity, <i>n</i> (%)	50	49 (5.1)	34 (3.7)	83 (4.4)
Waist circumference, [m (sd)]	55	55.98 (5.83)*** ^a	55.16 (5.90)	55.58 (5.88)
WHtR, [m (sd)]	55	0.45 (0.04)*	0.45 (0.04)	0.45 (0.04)
Abdominal obesity, <i>n</i> (%)	55	73 (7.5)	85 (9.2)	158 (8.4)
≥ 95 th percentile for %body fat, <i>n</i> (%)	55	128 (13.2)*** ^a	211 (22.9)	339 (18.0)
Parental characteristics				
Single parent, <i>n</i> (%)	265	82 (9.7)	95 (11.4)	177 (10.5)
Tertiary family educational level, <i>n</i> (%)	215	262 (31.8)	261 (32.5)	523 (32.1)
Household income ≤ €1,750, <i>n</i> (%)	452	101 (13.4)	106 (14.4)	207 (13.9)
Overweight/obesity (mother or father), <i>n</i> (%)	332	532 (65.0)	542 (68.3)	1074 (66.7)
Abdominal obesity (mother or father), <i>n</i> (%)	974	405 (82.7)	407 (85.0)	812 (83.8)
Smoking (mother or father), <i>n</i> (%)	270	309 (36.9)	319 (38.2)	628 (37.5)
Health awareness (mother or father), <i>n</i> (%)	343	541 (67.4)	539 (67.6)	1080 (67.5)
Health and lifestyle characteristics				
Skipping breakfast, <i>n</i> (%)	236	89 (10.4)**	134 (15.8)	223 (13.1)
Soft drinks > 1/week, <i>n</i> (%)	241	219 (25.6)	197 (23.3)	416 (24.4)
Playing outside > 60 min/day, <i>n</i> (%)	296	615 (73.8)***	515 (63.3)	1130 (68.6)
Physically active ≥ 4 days/week ≥ 60 min/day, <i>n</i> (%)	320	260 (31.7)***	177 (22.1)	437 (26.9)
Club sports > 1/week, <i>n</i> (%)	662	338 (52.0)	338 (53.6)	676 (52.8)
Screen media > 1 h/day, <i>n</i> (%)	250	173 (20.4)	146 (17.3)	319 (18.8)

NOTE. *m* mean, *sd* standard deviation, *BMI* body mass index, *BMIPERC* BMI percentiles, *WHtR* waist-to-height ratio

^aMann-Whitney-*U* test, **p* < 0.05, ***p* < 0.01, ****p* < 0.001

Table 2 Crude OR for independent variables taken into account in the generalized linear mixed regression model for skipping breakfast

	Missing Values	Crude OR	95% CI
Child characteristics			
Female gender	236	1.62	(1.22; 2.16)
Age > 7 years	281	1.04	(0.78; 1.37)
Migration background	303	3.60	(2.67; 4.84)
Overweight	471	2.02	(1.18; 3.43)
Obesity	286	1.94	(1.03; 3.66)
Abdominal obesity	290	2.51	(1.63; 3.88)
≥ 95 th percentile for %body fat	290	2.20	(1.58; 3.07)
Parental characteristics			
Single parent	271	2.45	(1.68; 3.58)
Tertiary family education level	321	0.34	(0.22; 0.50)
Household income ≤ €1,750	457	3.48	(2.46; 4.94)
Overweight/obesity (mother or father)	338	1.89	(1.33; 2.67)
Abdominal obesity (mother or father)	978	1.16	(0.66; 2.03)
Smoking (mother or father)	276	2.60	(1.94; 3.49)
Health awareness (mother or father)	349	0.70	(0.52; 0.96)
Health and lifestyle characteristics			
Soft drinks > 1/week	244	2.78	(2.07; 3.73)
Playing outside > 60 min/day	301	0.67	(0.50; 0.90)
Physically active ≥ 4 days/week ≥ 60 min/day	326	0.62	(0.43; 0.90)
Club sports > 1/week	667	1.03	(0.72; 1.48)
Screen media > 1 h/day	256	2.97	(2.18; 4.04)

NOTE. N = 1,943. OR odds ratio, CI confidence interval

between a logistic regression model and a generalized linear mixed model. Therefore, the model presented here is the generalized linear mixed model for binary outcomes, which accounts for the clustering of data in schools. Table 3 shows both the results of the full model and of sub-models for groups and behaviors for targeted preventive measures.

A higher level of physical activity and tertiary family education level showed lower odds for skipping breakfast. On the other hand, migration background, single parenthood, female gender, percentage of body fat at or above the 95th percentile, and frequent soft drink and screen media consumption had higher odds.

No significances were lost after dividing the full model into two separate sub-models for target groups and target behaviors. ORs in the sub-models were more pronounced than in the full model.

Further sub-models were calculated for boys and girls, they are depicted in Table 4.

The sub-model for girls showed higher odds for migration background, single parenthood, percentage of body fat at or above the 95th percentile, and frequent soft drink and screen media consumption. In the sub-model for boys lower odds were found for a higher level of physical activity and tertiary family education level.

Missing data

Participating children with missing data, significantly, more often had a migration background, lower results in the 6 min run test, and they differed in all anthropometric measurements from the ones with complete data. Participants with missing data had significantly higher BMI percentiles, more often were overweight and obese, and more often had a higher waist circumference and a higher WHtR. They also were more often abdominally obese and more often had a percentage of body fat at or above the 95th percentile than their counterparts. Finally, their parents were significantly more often single parents, less frequently had a tertiary educational level and more often a household income at or below €1,750.

Discussion

The study shows that migration background, living with a single parent, female gender, having a percentage of body fat at or above the 95th percentile, the consumption of soft drinks and high levels of screen media use are positively correlated with children skipping breakfast. Reaching high levels of physical activity and tertiary family education level are negatively correlated with skipping breakfast. Accordingly, interventions that influence the reported target behaviors as well as those that are tailored to the identified target groups are necessary. Behavioral changes can be addressed in all kinds of interventions at different levels. Differences between boys and girls should be taken into account according to the gender distribution in the respective target group.

First, parents should be informed about the importance of a healthy lifestyle and health-conscious behavior, such as responsible media consumption, sufficient physical activity, little or no soft drink consumption and most of all the importance of a regular breakfast. Furthermore, parents should be supported in their essential function as a role model for their children and demonstrate healthy breakfast habits. Therefore, interventions should synergistically promote children's health and involve their parents in order to be successful [32]. At an organizational level, teachers could inform parents about the need for regular and healthy breakfast for children at parents' evenings because there are positive effects of breakfast frequency and quality for both parents and children [33].

Some of the identified family-related factors for skipping breakfast are non- or hardly modifiable, like migration background, family education level and single parenthood.

Table 3 Generalized linear mixed models for skipping breakfast, full and sub-models for target groups and behaviors

	Full model (n = 1,441)		Sub-model target groups (n = 1,515)		Sub-model target behaviors (n = 1,612)	
	OR	95% CI	OR	95% CI	OR	95% CI
Migration background	2.39***	(1.68; 3.40)	2.81***	(2.02; 3.91)		
Tertiary family education level	0.55**	(0.35; 0.85)	0.42***	(0.28; 0.64)		
Single parent	2.17**	(1.33; 3.54)	2.13**	(1.34; 3.40)		
Female gender	1.53*	(1.07; 2.18)	1.43*	(1.03; 1.99)		
≥95 th percentile for %body fat	1.51 [†]	(0.99; 2.24)	1.47 [†]	(1.00; 2.17)		
Soft drinks > 1/week	2.41***	(1.70; 3.44)			2.49***	(1.81; 3.43)
Physically active ≥ 4 days/week ≥ 60 min/day	0.71	(0.47; 1.07)			0.64*	(0.44; 0.93)
Screen media > 1 h/day	1.91***	(1.31; 2.79)			2.48***	(1.77; 3.46)

NOTE. OR odds ratio, CI confidence interval

[†]p < .10; *p < .05; **p < .010; ***p < .001

Despite these difficult socioeconomic circumstances (e.g. poor housing, living and working conditions, worries, uncertainty) in which parents have to bring up their children, many of them may be aware of the importance of a healthy lifestyle but lack the necessary resources to implement it. The most promising way to reach children from families with these traits runs via settings like schools or kindergarten. The latter should offer regular breakfast at the start of a school or kindergarten day. In this way, all children are reached and skipping breakfast can be avoided. When developing measures for targeted prevention, there should be a special focus on the needs of the target groups identified in this study. Families in difficult socioeconomic circumstances need to be supported and provided with financial assistance for the payment of breakfast and/or other healthy meals at school. Thus, policy makers and intervention developers have to note that there are low-threshold and easily accessible opportunities required for reaching deprived target groups. Not least, policy makers should support healthy eating habits in schools and kindergartens at all times.

Relevance of breakfast in current research

Although the importance of breakfast consumption to young children's health is generally known, there is an increasing prevalence of children skipping breakfast [34, 35]. Food behaviors established in childhood are often continued into adulthood [36]. Therefore, it is necessary to identify the determinants of skipping breakfast. Based on these determinants, interventions for preventing skipping breakfast and promoting healthy dietary behaviors among children can be developed.

The parental role in the development of children's healthy breakfast behaviors is not questioned [37]. Pearson et al. report in their review on family correlates of breakfast consumption that parental breakfast intake is associated with the breakfast intake of their children [38]. Furthermore, they found out that living in two-parent families also has a positive influence on children's and adolescent's breakfast consumption [38]. The research from Wendy & Campbell also shows that children with single parents are more likely to skip breakfast than those with two parents [39]. These findings

Table 4 Generalized linear mixed models for skipping breakfast, sub-models for boys and girls

	Sub-model girls (n = 767)		Sub-model boys (n = 758)	
	OR	95% CI	OR	95% CI
Migration background	2.51***	(1.60; 3.93)	3.63***	(2.10; 6.28)
Tertiary family education level			0.36**	(0.17; 0.74)
Single parent	2.95***	(1.64; 5.31)		
≥95 th percentile for %body fat	1.56 [†]	(0.97; 2.52)		
Soft drinks > 1/week	2.12**	(1.33; 3.38)	2.88***	(1.68; 4.94)
Physically active ≥ 4 days/week ≥ 60 min/day			0.55 [†]	(0.29; 1.04)
Screen media > 1 h/day	2.62***	(1.60; 4.31)		

NOTE. OR odds ratio, CI confidence interval

[†]p < .10; *p < .05; **p < .010; ***p < .001

confirm the results of the present study that also found evidence for a relation between family structures and skipping breakfast. Therefore, it is important to consider family structures of the children when designing programs to promote healthy breakfast behavior's.

Associations between parenting and children's breakfast consumption were found for permission to skip breakfast and parental self-efficacy of skipping breakfast which were negatively associated with children's breakfast consumption [40]. Another study by Fugas et al. shows further reasons for skipping breakfast: lack of time, not being hungry in the morning and feeling unwell at the time of having breakfast are identified as explanations for skipping breakfast before going to school [41]. Similar to our findings that girls are more likely to skip breakfast than their male peers, other studies showed that breakfast consumption was more frequent among boys [42, 43]. This result could be explained by the likelihood that even young girls care more about their appearance and a slim figure [44]. A further study found out that adolescent boys and girls are more likely to skip breakfast if they perceived that their mothers often skip lunch [45]. Equal results are available for girls skipping breakfast with regard to their best friend's meal skipping behaviors. On the contrary, those who reported exemplary maternal healthy eating behaviors were less likely to skip breakfast [45]. These findings underline the importance of interventions to address parents, children and their peers simultaneously.

The investigations of Keski-Rahkonen et al. and Utter et al. show an association between skipping breakfast and having a higher BMI [43, 46]. Research on breakfast intake and abdominal obesity parameters are rare. Alexander et al. report that eating breakfast was associated with lower visceral adiposity in overweight Latino youth, aged 10 to 17 years [11]. In a survey of Iranian children and adolescents aged 6 to 18 years the percentage of abdominal obesity in breakfast skippers was almost 5 percentage points higher than in non-skippers [47]. A French study in primary schoolchildren showed that those who regularly eat breakfast had the lowest waist circumferences [48].

There are many studies showing a positive relationship between skipping breakfast and a low socioeconomic status [42, 49]. In the present study, children with migration background were more likely to skip breakfast than their counterparts and a tertiary family education level was positively associated with having breakfast.

Children who spend more time in front of screen media and are less physically active are more likely to skip breakfast than their peers. These results are in line with the results of a study by Tin et al. in Hongkong with primary schoolchildren [49] and the study of Timlin et al. with adolescents [42]. Only one study found no relation between physical activity and skipping breakfast

[43]. TV viewing during meals and the consumption of sugar sweetened beverages along with skipping breakfast were associated with significantly higher waist circumferences in French primary schoolchildren [48].

The probability of skipping breakfast increased with age [1]. The present study could not detect associations between age and skipping breakfast, probably because of the restricted variation in the age of the participating primary schoolchildren.

Last but not least, there should also be a focus on general meal patterns and obesity. Not just skipping breakfast is associated with obesity but a wide range of obesogenic behaviors influences weight status. Berg et al. showed an association between obesity and skipping breakfast, skipping lunch or eating at night. Larger self-reported portion size was also related to obesity. However, the investigation showed no significant relationship with intake of total energy [50]. Other authors emphasized that large, high energy-dense portions favor obesogenic eating behaviors in children [51]. Moreover, serving children large entrée portion sizes increases total energy intake but without decreases in intake of other foods. If children can self-select and limit their food intake, energy intake will decrease [52]. In this context, it seems necessary not only to consider breakfast skipping children when providing healthy breakfast at school. Attention should also be attached to children who had breakfast previously to avoid a higher intake of energy that might aggravate the situation and would be counterproductive in obesity prevention.

In summary, our study contributes to the body of evidence that exists for factors associated with skipping breakfast in primary schoolchildren. We identified vulnerable groups for targeted prevention and behavioral aspects, which need to be addressed in addition with preventing children from skipping breakfast. Therefore, the current results play an important role for developing targeted preventive measures for skipping breakfast in primary schoolchildren.

Strengths and limitations

This research provides a valuable contribution in exploring determinants for the prevention of skipping breakfast in schoolchildren. However, some aspects should be considered when interpreting these findings.

Anthropometric measurements of the children were taken in a standardized manner according to a protocol by specially trained staff. Data management and statistical advice was provided by the Institute of Epidemiology and Medical Biometry at Ulm University. However, a limiting factor is the cross-sectional character of this research that precludes any causal interpretations of the results because cross-sectional studies do not allow conclusions about the direction of the detected associations.

Parents did not completely fill in questionnaires therefore missing values occurred. In observational studies, missing data are a frequently arising problem and may possibly bias the results. Therefore, the study examined the specific differences between those participants with missing and those with complete data. Considering these differences, children with missing data show several critical characteristics: They have higher rates of migration background and abdominal obesity, and less frequently a tertiary educational level. If these participants could have been included in the regression analysis for correlates of skipping breakfast, it might have accentuated the results. In this research, only schoolchildren whose teachers gave their agreement to participate were involved. Furthermore, due to the voluntary participation, only 62% of parents of eligible children gave their consent. Thus data from over a third of eligible children could not be collected. It may be assumed that there are differences between children who participated in the study and those who failed. This may contribute to the missing data bias.

In common with studies with an observational character, some unintentional bias may compromise the results. As already mentioned, only schoolchildren whose teachers and parents gave their agreement to participate were studied. Therefore, a twofold selection bias may have occurred on behalf of the teachers deciding to opt in and parents giving their consent for participation. Recall bias and social desirability bias may affect the parental report concerning the offspring's patterns of physical activity, screen media use and consumption of soft drinks as well as breakfast habits. Parental breakfast was not assessed in the present study, but should be included in future research. Furthermore, the way skipping breakfast was assessed is a limitation of the study. Although the results are not representative for the whole of Germany, the sample size and the fact that this research comprises of data from an entire federal state of Germany are great strengths of the study. Response rates from participating parents with 87% at baseline were remarkably high. The study thus provides a valuable contribution for exploring determinants in the prevention of skipping breakfast in schoolchildren.

Conclusion

Skipping breakfast contributes to the epidemic rise in childhood obesity. Therefore, it should be addressed in targeted interventions. Children, parents and teachers should be involved in those interventions preventing obesity and promoting health-conscious behavior and a healthy lifestyle. A special focus has to be given to girls, those who are already obese, have a migration background or a single parent and no tertiary family education level. Further crucial behaviors that are linked to breakfast

habits as well as to obesity, and have to be addressed are physical activity, screen media use and consumption of soft drinks. Positive knowledge about breakfast consumption should be built up. Promoting and providing a healthy breakfast at school may particularly help breakfast skippers and should lie even in the interest of policymakers.

Abbreviations

BMI: Body mass index; CASMIN: Comparative Analysis of Social Mobility in Industrial Nations; DRKS: German Clinical Trials Register; HOMA-IR: Homeostasis model assessment of insulin resistance index; ISAK: International Standards for Anthropometric Assessment; KiGGS: German Health Interview and Examination Survey for Children and Adolescents; NCD: Non-communicable disease; OR: Odds ratio; WC: Waist circumference; WHO: World Health Organization; WHtR: Waist-to-height ratio

Acknowledgments

Thanks to all members of the "Join the Healthy Boat – primary school" research group for their input. Most of all, we thank the teachers, pupils and their parents who participated in the Baden-Württemberg Study. Finally, we thank Sinéad McLaughlin for her language assistance.

Funding

The program "Join the Healthy Boat – primary school" is financed by the Baden-Württemberg Stiftung. The Baden-Württemberg Stiftung had no influence on the content of the manuscript.

Availability of data and materials

The datasets generated and analysed during the current study are not publicly available due to reasons of data protection but are available from the Institute of Epidemiology and Medical Biometry, Ulm University, on reasonable request.

Authors' contributions

DK and other members of the research group planned and organized the Baden-Württemberg study, and were involved in carrying out the measurements in fall 2010. DK and MT performed the statistical analyses. JMS is the director of the program "Join the Healthy Boat – primary school" and principal investigator of the Baden-Württemberg Study. DK, MT and RL drafted the manuscript. TK and JMS revised the manuscript drafts. All authors have read and approved the final version of the manuscript.

Competing interest

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

The study protocol was approved by the ethics committee of Ulm University in June 2009 (Application No. 126/10). The Baden-Württemberg Study is registered at the German Clinical Trials Register (DRKS) Freiburg University, Germany, under the DRKS-ID: DRKS00000494. Written informed consent was obtained from parents and teachers.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

¹Division of Sport and Rehabilitation Medicine, Ulm University Medical Center, 89075 Ulm, Germany. ²Institute of General Medicine, Ulm University, Helmholtzstraße 20, D-89081 Ulm, Germany. ³Department of Computer Science, Ulm University of Applied Sciences, 89081 Ulm, Germany.

Received: 16 August 2016 Accepted: 3 March 2017

Published online: 14 March 2017

References

- Szajewska H, Ruszczyński M. Systematic review demonstrating that breakfast consumption influences body weight outcomes in children and adolescents in Europe. *Crit Rev Food Sci Nutr*. 2010;50(2):113–9.
- de la Hunty A, Gibson S, Ashwell M. Does regular breakfast cereal consumption help children and adolescents stay slimmer? a systematic review and meta-analysis. *Obes Facts*. 2013;6(1):70–85.
- Baldinger N, Krebs A, Müller R, Aeberli I. Swiss children consuming breakfast regularly have better motor functional skills and are less overweight than breakfast skippers. *J Am Coll Nutr*. 2012;31(2):87–93.
- Wesnes KA, Pincock C, Scholey A. Breakfast is associated with enhanced cognitive function in schoolchildren. An internet based study. *Appetite*. 2012;59(3):646–9.
- Donin AS, Nightingale CM, Owen CG, Rudnicka AR, Perkin MR, Jebb SA, et al. Regular breakfast consumption and type 2 diabetes risk markers in 9- to 10-year-old children in the child heart and health study in England (CHASE): a cross-sectional analysis. *PLoS Med*. 2014;11(9):e1001703.
- Karatzis K, Moschonis G, Barouti A-A, Lionis C, Chrousos GP, Manios Y. Dietary patterns and breakfast consumption in relation to insulin resistance in children. *The Healthy Growth Study*. *Public Health Nutr*. 2014;17(12):2790–7.
- Freitas Júnior IF, Christofaro DGD, Codogno JS, Monteiro PA, Silveira LS, Fernandes RA. The association between skipping breakfast and biochemical variables in sedentary obese children and adolescents. *J Pediatr*. 2012;161:871–4.
- Barr SI, DiFrancesco L, Fulgoni VL. Breakfast consumption is positively associated with nutrient adequacy in Canadian children and adolescents. *Br J Nutr*. 2014;112(8):1373–83.
- Kesztyüs D, Traub M, Lauer R, Kesztyüs T, Steinacker JM. Correlates of longitudinal changes in the waist-to-height ratio of primary school children: Implications for prevention. *Prev Med Reports*. 2016;3:1–6.
- Alexander KE, Ventura EE, Spruijt-metz D, Weigensberg MJ, Goran MI, Davis JN. Indices in Overweight Latino Youth. *Obesity* (Silver Spring). 2010;17(8):1528–33.
- Hainer V, Aldhoon-Hainerova I. Obesity paradox does exist. *Diabetes Care*. 2013;36 Suppl 2:S276–81.
- Bloom DE, Cafiero E, Jané-Llopis E, Abrahams-Gessel S, Reddy Bloom L, Fathima S, et al. The Global Economic Burden of Noncommunicable Diseases. In: *World Economic Forum*. 2011. [w3.weforum.org/docs/WEF_Global_EconomicBurdenNonCommunicableDiseases_2011.pdf](http://www.weforum.org/docs/WEF_Global_EconomicBurdenNonCommunicableDiseases_2011.pdf). Accessed 8 Mar 2017.
- Coutinho T, Goel K, Corrêa De Sá D, Carter RE, Hodge DO, Kragelund C, et al. Combining body mass index with measures of central obesity in the assessment of mortality in subjects with coronary disease: Role of "normal weight central obesity". *J Am Coll Cardiol*. 2013;61(5):553–60.
- Javed A, Jumean M, Murad MH, Okorodudu D, Kumar S, Somers VK, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: A systematic review and meta-analysis. *Pediatr Obes*. 2015;10(3):234–44.
- Griffiths C, Gately P, Marchant PR, Cooke CB. A five year longitudinal study investigating the prevalence of childhood obesity: Comparison of BMI and waist circumference. *Public Health*. 2013;127:1090–6.
- Kesztyüs D, Wirt T, Kobel S, Schreiber A, Kettner S, Dreyhaupt J, et al. Is central obesity associated with poorer health and health-related quality of life in primary school children? Cross-sectional results from the Baden-Württemberg Study. *BMC Public Health*. 2013;13:260.
- Rampersaud GC, Pereira MA, Girard BL, Adams J, Metz J. Breakfast habits, nutritional status, body weight, and academic performance in children and adolescents. *J Am Diet Assoc*. 2005;105(5):743–60.
- Kesztyüs D, Schreiber A, Wirt T, Wiedom M, Dreyhaupt J, Brandstetter S, et al. Economic evaluation of URME-ICE, a school-based overweight prevention programme comprising metabolism, exercise and lifestyle intervention in children. *Eur J Heal Econ*. 2013;14(2):185–95.
- Dreyhaupt J, Koch B, Wirt T, Schreiber A, Brandstetter S, Kesztyüs D, et al. Evaluation of a health promotion program in children: Study protocol and design of the cluster-randomized Baden-Wuerttemberg primary school study [DRKS-ID: DRKS0000494]. *BMC Public Health*. 2012;12(1):157.
- Brauns H, Steinmann S. Educational reform in France, West-Germany and the United Kingdom: updating the CASMIN educational classification. *ZUMA Nachrichten*. 1999;23:7–44.
- Lange M, Kamtsiuris P, Lange C, Rosario AS, Stolzenberg H, Lampert T. Messung soziodemographischer Merkmale im Kinder- und Jugendgesundheitsurvey (KiGGS) und ihre Bedeutung am Beispiel der Einschätzung des allgemeinen Gesundheitszustands [Sociodemographic characteristics in the German Health Interview and Examination Survey. *Bundesgesundheitsblatt Gesundheitsforsch Gesundheitsschutz*. 2007; 50(5–6):578–89.
- Kurth B-M. Der Kinder- und Jugendgesundheitsurvey (KiGGS): Ein Überblick über Planung, Durchführung und Ergebnisse unter Berücksichtigung von Aspekten eines Qualitätsmanagements TL - 50. *Bundesgesundheitsblatt Gesundheitsforsch Gesundheitsschutz*. 2007;50(5–6):533–46.
- World Health Organization. Global recommendations on physical activity for health. In: *WHO Global Strategy on Diet, Physical Activity and Health*. 2010. http://apps.who.int/iris/bitstream/10665/44399/1/9789241599979_eng.pdf. Accessed 04 June 2016.
- Stewart A, Marfell-Jones M, Olds T, De Ridder H. International standards for anthropometric assessment. In: *International Standards for Anthropometric Assessment*. International Society for the Advancement of Kinanthropometry. 2011. <http://www.ceap.br/material/MAT17032011184632.pdf>. Accessed 04 June 2016.
- Kromeyer-Hauschild K, Wabitsch M, Kunze D, Geller F, Geiß HC, Hesse V, et al. Perzentile für den Body-mass-Index für das Kindes- und Jugendalter unter Heranziehung verschiedener deutscher Stichproben [Percentiles of body mass index in children and adolescents evaluated from different regional German studies]. *Monatsschrift Kinderheilkd*. 2001;149:807–18.
- McCarthy HD, Ashwell M. A study of central fatness using waist-to-height ratios in UK children and adolescents over two decades supports the simple message—'keep your waist circumference to less than half your height'. *Int J Obes*. 2006;30:988–92.
- Nambiar S, Hughes I, Davies PS. Developing waist-to-height ratio cut-offs to define overweight and obesity in children and adolescents. *Public Health Nutr*. 2010;13(10):1566–74.
- World Health Organisation. Physical status: the use and interpretation of anthropometry. In: *Report of a WHO Expert Committee*. WHO Technical Report Series 854. 1995. http://apps.who.int/iris/bitstream/10665/37003/1/WHO_TRS_854.pdf. Accessed 04 June 2016.
- Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *Int J Food Sci Nutr*. 2005;56(5):303–7.
- Vandenbroucke JP, Von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): Explanation and elaboration. *PLoS Med*. 2007;4(10):1628–54.
- Eldridge SM, Ukoumunne OC, Carlin JB. The intra-cluster correlation coefficient in cluster randomized trials: a review of definitions. *Int Stat Rev*. 2009;77:378–94.
- Vasques C, Magalhães P, Cortinhas A, Mota P, Leitao J, Lopes VP. Effects of intervention programs on child and adolescent BMI: a meta-analysis study. *J Phys Act Health*. 2014;11(2):426–44.
- Pereira MA, Erickson E, Mckee P, Schrankler K, Raatz SK, Lytle LA, et al. Breakfast frequency and quality May affect glycemia and appetite in adults and children 1–4. *J Nutr*. 2011;141(1):163–8.
- Shaw ME. Adolescent breakfast skipping : an australian study. *Adolescence*. 1998;33(132):851–61.
- Nicklas TA, Bao W, Webber LS, Berenson GS. Breakfast consumption affects adequacy of total daily intake in children. *J Am Diet Assoc*. 1993;93(8):886–91.
- Mikkilä V, Räsänen L, Raitakari OT, Pietinen P, Viikari J. Longitudinal changes in diet from childhood into adulthood with respect to risk of cardiovascular diseases: the cardiovascular risk in young finns study. *Eur J Clin Nutr*. 2004;58:1038–45.
- van der Horst K, Oenema A, Ferreira I, Wendel-Vos W, Giskes K, van Lenthe F, et al. A systematic review of environmental correlates of obesity-related dietary behaviors in youth. *Health Educ Res*. 2007;22(2):203–26.
- Pearson N, Biddle SJH, Gorely T. Family correlates of breakfast consumption among children and adolescents. A systematic review. *Appetite*. 2009;52(1):1–7.
- Wolfe WS, Campbell CC. Food pattern, diet quality, and related characteristics of schoolchildren in New York State. *J Am Diet Assoc*. 1993;93(11):1280–4.

40. Van Lippevelde W, Te Velde SJ, Verloigne M, Van Stralen MM, De Bourdeaudhuij I, Manios Y, et al. Associations between family-related factors, breakfast consumption and BMI among 10- to 12-year-Old european children: the cross-sectional ENERGY-study. *PLoS One*. 2013;8(11):1–8.
41. Fugas V, Berta E, Walz F, Fortino A, Martinelli MJ. Breakfast habit and quality in students from two public primary schools in the city of Santa Fe. *Arch Argent Pediatr*. 2013;111(6):502–7.
42. Timlin MT, Pereira MA, Story M, Neumark-Sztainer D. Breakfast eating and weight change in a 5-year prospective analysis of adolescents: project EAT. *Pediatrics*. 2008;121(3):e638–45.
43. Utter J, Scraagg R, Mhurchu CN, Schaaf D. At-home breakfast consumption among New index and related nutrition behaviors. *J Am Diet Assoc*. 2007;107(6):570–6.
44. Ricciardelli LA, McCabe MP. Children's body image concerns and eating disturbance: a review of the literature. *Clin Psychol Rev*. 2001;21(3):325–44.
45. Pearson N, Williams L, Crawford D, Ball K. Maternal and best friends' influences on meal-skipping behaviours. *Br J Nutr*. 2012;108(5):932–8.
46. Keski-Rahkonen A, Kaprio J, Rissanen A, Virkkunen M, Rose RJ. Breakfast skipping and health-compromising behaviors in adolescents and adults. *Eur J Clin Nutr*. 2003;57(7):842–53.
47. Ahadi Z, Qorbani M, Kelishadi R, Ardalan G, Motlagh ME, Asayesh H, et al. Association between breakfast intake with anthropometric measurements, blood pressure and food consumption behaviors among Iranian children and adolescents: the CASPIAN-IV study. *Public Health*. 2015;129(6):740–7.
48. Isacco L, Lazaar N, Ratel S, Thivel D, Aucouturier J, Doré E, et al. The impact of eating habits on anthropometric characteristics in French primary school children. *Child Care Health Dev*. 2010;36(6):835–42.
49. Tin S, Ho S, Mak K, Wan K, Lam T. Lifestyle and socioeconomic correlates of breakfast skipping in Hong Kong primary 4 schoolchildren. *Prev Med (Baltim)*. 2011;52(3–4):250–3.
50. Berg C, Lappas G, Wolk A, Strandhagen E, Toren K, Rosengren A, Thelle D, Lissner L. Eating patterns and portion size associated with obesity in a Swedish population. *Appetite*. 2009;52(1):21–6.
51. Fisher JO, Kral TV. Super-size me: Portion size effects on young children's eating. *Physiol Behav*. 2008;94(1):39–47.
52. Fisher JO, Rolls BJ, Birch LL. Children's bite size and intake of an entrée are greater with large portions than with age-appropriate or self-selected portions. *Am J Clin Nutr*. 2003;77(5):1164–70.

Submit your next manuscript to BioMed Central and we will help you at every step:

- We accept pre-submission inquiries
- Our selector tool helps you to find the most relevant journal
- We provide round the clock customer support
- Convenient online submission
- Thorough peer review
- Inclusion in PubMed and all major indexing services
- Maximum visibility for your research

Submit your manuscript at
www.biomedcentral.com/submit



9.3 Traub M, Lauer R, Kesztyues T, Wartha O, Steinacker JM, Kesztyues D. *Skipping breakfast, overconsumption of soft drinks and screen media: longitudinal analysis of the combined influence on weight development in primary schoolchildren. BMC Public Health. 2018; 18:363.*

Open Acces Artikel

Leistungsbereich	Eigenanteil	Anteil anderer Personen	Spezifizierung des Eigenanteils
Auswertung (Analyse)	40 %	Koautoren, 60 %	Durchführung statistischer Analysen
Manuskript	80 %	Koautoren, 20 %	Erstellung des Manuskripts

RESEARCH ARTICLE

Open Access



Skipping breakfast, overconsumption of soft drinks and screen media: longitudinal analysis of the combined influence on weight development in primary schoolchildren

Meike Traub^{1*}, Romy Lauer¹, Tibor Kesztyüs^{3,4}, Olivia Wartha¹, Jürgen Michael Steinacker¹, Dorothea Kesztyüs^{1,2} and the Research Group "Join the Healthy Boat"

Abstract

Background: Regular breakfast and well-balanced soft drink, and screen media consumption are associated with a lower risk of overweight and obesity in schoolchildren. The aim of this research is the combined examination of these three parameters as influencing factors for longitudinal weight development in schoolchildren in order to adapt targeted preventive measures.

Methods: In the course of the Baden-Württemberg Study, Germany, data from direct measurements (baseline (2010) and follow-up (2011)) at schools was available for 1733 primary schoolchildren aged 7.08 ± 0.6 years (50.8% boys). Anthropometric measurements of the children were taken according to ISAK-standards (International Standard for Anthropometric Assessment) by trained staff. Health and lifestyle characteristics of the children and their parents were assessed in questionnaires. A linear mixed effects regression analysis was conducted to examine influences on changes in waist-to-height-ratio (WHtR), weight, and body mass index (BMI) measures. A generalised linear mixed effects regression analysis was performed to identify the relationship between breakfast, soft drink and screen media consumption with the prevalence of overweight, obesity and abdominal obesity at follow-up.

Results: According to the regression analyses, skipping breakfast led to increased changes in WHtR, weight and BMI measures. Skipping breakfast and the overconsumption of screen media at baseline led to higher odds of abdominal obesity and overweight at follow-up. No significant association *between soft drink consumption and weight development was found*.

Conclusion: Targeted prevention for healthy weight status and development in primary schoolchildren should aim towards promoting balanced breakfast habits and a reduction in screen media consumption. Future research on soft drink consumption is needed. Health promoting interventions should synergistically involve children, parents, and schools.

Trial registration: The Baden-Württemberg Study is registered at the German Clinical Trials Register (DRKS) under the DRKS-ID: [DRKS00000494](https://www.drks.de/DRKS00000494).

Keywords: Child, Soft drink, Breakfast, Screen media, Overweight, Obesity, Prevention & control

* Correspondence: meike.traub@uni-ulm.de

¹Medical Center, Division of Sports and Rehabilitation Medicine, University of Ulm, Frauensteige 6, Haus 58/33, 89075 Ulm, Germany
Full list of author information is available at the end of the article



© The Author(s). 2018 **Open Access** This article is distributed under the terms of the Creative Commons Attribution 4.0 International License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated.

Background

The increase in overweight and obesity in children and adolescents as a worldwide health problem [1] has led the World Health Organization (WHO), in the introduction of its World Health Report, to define overweight and obesity as one of the future challenges [2]. In particular, childhood obesity has the longer-term risk that overweight or obese children become overweight adults and develop, e.g., cardiovascular diseases, diabetes or orthopaedic problems [3]. Overweight and obesity are most often the result of an unhealthy lifestyle, leading to a rising prevalence of non-communicable diseases (NCD) [4]. It is assumed that abdominal obesity has the most risky influence on the development of NCDs [5]. There are multiple and complex reasons for overweight and obesity. However, in addition to genetic and physiologic aspects, lifestyle patterns are the most frequent causes of weight gain. In particular, a sedentary lifestyle with a lot of screen media consumption and reduced physical activity [6, 7] skipping breakfast [8], and a high energy intake, e.g. overconsumption of high-calorie soft drinks [7] seem to be relevant factors for weight gain and the development of overweight in primary schoolchildren. Systematic reviews show that in schoolchildren skipping breakfast is associated with an increase in body mass index (BMI) and a higher risk of becoming overweight or obese [8, 9]. In addition, there exists the general view that prolonged use of screen media is associated with childhood obesity [10]. On the one hand, time spent with screen media leads to physical inactivity, and on the other hand, it contributes to an increased energy intake through snacking and consuming soft drinks in front of the screen [10]. A study of Krahnstoever Davison et al. shows that 7-year-old girls who exceed the recommendations of the tolerable time watching TV are more likely to be overweight at age 11 [11]. Due to the high calorific density of soft drinks, there is a special interest in the association of soft drink consumption and obesity [12]. Two recent reviews conclude that the consumption of soft drinks is related to obesity [13, 14]. Additionally, the association between soft drink consumption and various weight parameters is consistent [15]. For example, Lee et al. confirm a link between high soft drink consumption and higher waist circumference (WC) and BMI z-scores [16].

The aim of the present study is to investigate the longitudinal associations of skipping breakfast, the consumption of soft drinks, and screen media as combined factors for longitudinal weight development in schoolchildren. New information for multicomponent and targeted interventions for obesity prevention in schoolchildren could be derived from these findings.

Methods

Study design

The Baden-Württemberg Study is a prospective, cluster-randomized and longitudinal study with a waitlist control group to evaluate the school-based health promotion programme “Join the Healthy Boat”. The programme is included in the curriculum of grades one to four at primary schools in Baden-Württemberg, south-west Germany. A detailed description of the evaluation design and the programme can be found elsewhere [17]. The aim of the programme is to support children to develop a healthy lifestyle in the terms of physical activity, reduction in consumption of soft drinks and in screen media. Behavioural and environmental components are combined equally. In order to analyse the success of the programme and its effects, data collection was conducted for baseline measurements in autumn 2010, and for follow-up in autumn 2011.

Ethics, consent and permissions

Besides the agreement of schools and teachers to participate in the study, parents had to give their written, informed consent for their child. The trial protocol was approved by the ethics committee of Ulm University (Application No. 126/10). The Baden-Württemberg Study is registered at the German Clinical Trials Register (DRKS) under the DRKS-ID: DRKS00000494.

Participants and data

At baseline and follow-up, data from 1733 children from first and second grade was collected. Anthropometric data of the children such as height, weight, and waist circumference were assessed in schools by trained staff. Data from parental questionnaires was available for 1545 children (89%) at baseline and follow-up. Parents gave information about their own anthropometric data as well as health and living conditions. They also provided details about their child's health behaviour, lifestyle and socioeconomic background.

Demographics

The parental education level was assigned on the basis of the CASMIN classification (Comparative Analysis of Social Mobility in Industrial Nations) [18], and family education level was defined as the highest level of two parents or a single parent. Family education level was dichotomized for analysis into elementary and intermediate level, on the one side, compared with tertiary level on the other side. A child's migration background was defined as at least having one parent being born abroad, or at least one parent having mainly spoken a foreign language and not German during the child's first years of life. Household income was assessed according to the categories used in the KiGGS survey (German Health Interview and

Examination Survey for Children and Adolescents) [19] and dichotomized for analysis into two groups: Families with a household income of €1750 or less per month, and families with more than €1750 per month.

Health and lifestyle characteristics

Parents were asked to give information on their children's health and health behaviour. Relevant questions were taken from the validated questionnaires of the German KiGGS survey [20]. Frequency of consuming soft drinks at school and outside school (several times a day, every day, several times a week, once a week, less than once a week, never) was assessed on a 6-point Likert scale. Time spent with screen media on school days and at weekends, as well as playing outside (never, about 30 min/day, about 30–60 min/day, about 1–2 h/day, about 2–3 h/day, about 3–4 h/day, more than 4 h/day) was assessed on a 7-point Likert scale. Variables were dichotomized for analysis (soft drinks > 1/week, playing outside > 60 min/day, screen media > 1 h/day). On a 4-point Likert scale, parents stated how often their children ate breakfast before going to school. The answers also were dichotomized: "Never and rarely" versus "often and always". Furthermore, they stated the number of days per week during which their children were physically active at a moderate to vigorous level for at least 60 min a day, as recommended by the World Health Organization (WHO) [21]. This item was dichotomized for analysis at the middle category (physically active ≥ 4 days/week ≥ 60 min/day). Moreover, parents were asked whether and how long their children were breastfed, and whether their mother had smoked during pregnancy. Finally, parents stated self-assessed information about their height, weight and WC, from which their weight status could be derived.

Anthropometric measurements

Trained staff took the anthropometric measurements of the children according to ISAK-standards [22]. Height was measured to the nearest 0.1 cm and body weight was assessed to the nearest 0.1 kg using a stadiometer (Stadiometer, Seca®, Germany) and an electric calibrated and balanced scale (Seca®, Germany). WC was measured midway between iliac crest and lower costal arch to the nearest 0.1 cm using a flexible metal tape (Lufkin Industries Inc., Texas, USA). The children's BMI was computed as weight divided by height squared (kg/m^2). According to German reference data, cut-off points for overweight children were set above the 90th age- and gender-specific BMI percentile; for obese children above the 97th percentile [23]. WC divided by height in centimetres was used to calculate the waist-to-height-ratio (WHtR). According to Ashwell & Hsieh, participants with a WHtR ≥ 0.5 were categorized as abdominally

obese [24]. Parental BMI was determined based on the self-reported weight and height data from the questionnaires and was categorized as overweight (BMI ≥ 25.0) or obese (BMI ≥ 30.0) [25]. Parental WHtR was calculated as the ratio of self-reported WC to height in centimetres, and the cut-off point for abdominal obesity was defined as WHtR ≥ 0.5 [24].

Missing data

In observational studies the problem of missing data often occurs, possibly leading to biased results [26]. Therefore, baseline differences between cases with and without missing values for the final regression model were statistically tested and reported.

Statistical analysis

Group differences in baseline data between boys and girls, as well as between participants with and without missing values, were tested. The Mann-Whitney-U test was used for continuous data, and Fisher's exact test for categorical data. Statistical analyses were performed using the statistical software packages IBM SPSS Release 21.0 for Windows (SPSS Inc, Chicago, IL, USA) with a significance level set at $\alpha = 0.05$ for two-sided tests.

To account for the clustering of data in schools, generalised linear mixed effects models were calculated for the prevalence of abdominal obesity, overweight and obesity at follow-up. Changes in WHtR, weight in kg and BMI measures were analysed in linear mixed effects regression analyses. Variables from models derived in previous investigations were included in the analyses [27, 28]. The variables of interest were included in the respective model for each outcome parameter and were tested for their significance. Because of multiple testing and the accumulation of α -error, a Bonferroni-Holm correction was applied [29]. For this purpose, the ascending ordered quantity k (= number of single hypotheses) of the p -values were subjected to the rule of significance $p < \alpha / k$, where k has been reduced by 1 in each further step.

Results

Baseline characteristics

Table 1 shows a summary of baseline participants' anthropometric, health and lifestyle characteristics. Primary schoolchildren who took part in the research had a mean age of 7.08 ± 0.6 years, 50.8% of them were boys. Boys were significantly heavier and less abdominally obese than girls, but on average had a higher WC. Significantly more mothers of girls refrained from smoking than did mothers of boys. Boys played outside significantly more often, reached significantly higher levels of physical activity, and spent significantly more time with screen media than did girls. Girls skipped breakfast significantly more often than did boys.

Table 1 Baseline characteristics of participants in the Baden-Württemberg Study (2010-2011)

	Missing Values	Girls (n=852)	Boys (n=881)	Total (n=1733)
Child characteristics				
Age, years [m (sd)]		7.07 (0.64)	7.09 (0.63)	7.08 (0.63)
Migration background, n (%)	244	235 (31.6)	227 (30.5)	462 (31.0)
Control group, n (%)		371 (43.5)	407 (46.2)	778 (44.9)
Weight in kg [m (sd)]		24.45 (4.50)**	24.88 (4.82)	24.67 (4.91)
BMI, [m (sd)]		15.99 (2.19)	15.97 (2.08)	15.98 (2.14)
BMIPERC, [m (sd)]		48.96 (27.74)	48.15 (27.57)	48.55 (27.65)
Overweight, n (%)		82 (9.6)	83 (9.4)	165 (9.5)
Obesity, n (%)		30 (3.5)	38 (4.3)	68 (3.9)
WC, cm [m (sd)]		55.15 (5.91)*	55.79 (5.54)	55.48 (5.73)
WHtR, [m (sd)]		0.45 (0.04)	0.45 (0.04)	0.45 (0.04)
Abdominal obesity, n (%)		78 (9.2)*	57 (6.5)	135 (7.8)
Parental characteristics				
Single parent, n (%)	218	85 (11.3)	71 (9.3)	156 (10.3)
Maternal smoking during pregnancy, n (%)	196	65 (8.5)*	91 (11.8)	156 (10.1)
Breastfeeding, n (%)	194	651 (85.1)	535 (82.0)	1286 (83.6)
Breastfeeding months [m (sd)]	462	5.55 (3.46)	5.68 (4.05)	5.61 (3.76)
Tertiary family educational level, n (%)	269	237 (32.6)	238 (32.3)	475 (32.4)
Household income ≤ 1750 €, n (%)	381	88 (13.1)	83 (12.2)	171 (12.6)
Overweight (mother), n (%)	300	223 (31.4)	217 (30.1)	440 (30.7)
Overweight (father), n (%)	392	417 (62.8)	400 (59.1)	817 (60.9)
Abdominal obesity (mother), n (%)	788	228 (48.1)	219 (46.5)	447 (47.3)
Abdominal obesity (father), n (%)	871	325 (76.3)	317 (72.7)	642 (74.5)
Health and lifestyle characteristics				
Playing outside > 60 min/day, n (%)	248	462 (62.9)***	558 (74.4)	1020 (68.7)
Physically active ≥ 4 days/week ≥ 60 min/day, n (%)	263	161 (22.1)***	238 (32.1)	399 (27.1)
Screen media > 1 h/day, n (%)	205	86 (11.3)*	119 (15.5)	205 (13.4)
PC on school days > 1 h/day, n (%)	246	2 (0.3)**	14 (1.9)	16 (1.1)
PC at weekends > 1 h/day, n (%)	236	28 (3.7)***	72 (9.6)	100 (6.7)
TV on school days > 1 h/day, n (%)	217	89 (11.8)*	124 (16.3)	213 (14.1)
TV at weekends > 1 h/day, n (%)	228	362 (48.1)	390 (51.8)	752 (50.0)
Soft drinks > 1 time per week n (%)	197	178 (23.3)	198 (25.7)	376 (24.5)
At school, n (%)	226	57 (7.5)	52 (6.9)	109 (7.2)
Outside school, n (%)	224	174 (23.3)	192 (25.2)	366 (24.3)
Skipping breakfast, n (%)	195	116 (15.2)**	82 (10.6)	198 (12.9)

m (sd) mean (standard deviation), BMI body mass index, BMIPERC BMI percentiles, WHtR waist-to-height-ratio, WC waist circumference

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$ **Regression analysis of changes in WHtR, weight and BMI measures**

Previous investigations of the same study were taken as the basis for the regression model used here [27, 28]. A linear mixed effects regression model was formed for each outcome parameter and the variables of interest

were tested for their statistical significance. Table 2 shows the longitudinal correlations of skipping breakfast, and the overconsumption of soft drinks and screen media with changes in WHtR, weight in kg and BMI percentiles, adjusted for the respective baseline measures, for socio-economic (migration background, household

Table 2 Linear mixed regression models of longitudinal changes in WHtR, weight in kg and BMI percentiles

	Changes in WHtR* ¹ †		Changes in weight* ² [kg]		Changes in BMI percentiles* ³	
	(n = 1252)		(n = 1251)		(n = 1250)	
	B (SE)	p-value	B (SE)	p-value	B (SE)	p-value
Skipping breakfast	0.50 (0.19)	0.007**	0.39 (0.12)	<0.001***	2.01 (0.90)	0.027*
Soft drinks > 1 time per week	-0.01 (0.15)	0.966	-0.08 (0.09)	0.385	-0.75 (0.70)	0.282
Screen media > 1 h/day	0.29 (0.16)	0.074	0.19 (0.10)	0.054	0.70 (0.78)	0.373

B (SE) B regression coefficient (standard error), † multiplied by 10^2 for better interpretability, *adjusted for school, migration background, family education level, household income, age, gender, participation in the intervention, and ¹baseline WHtR, ²baseline weight, ³baseline BMI percentiles

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

income, and family education level) and individual (age and gender) variables, and assignment to the intervention or control group of the underlying programme evaluation and school. Children who skipped breakfast were significantly more likely to show increases in WHtR, in weight, and in BMI percentiles.

Skipping breakfast also influenced changes in BMI (0.21 ± 0.01 , $p = 0.006$) and BMI z-scores (0.09 ± 0.03 , $p = 0.001$).

Regression model for prevalent abdominal obesity, overweight and obesity at follow-up

Table 3 shows the results of the generalised linear mixed regression analysis for the possible influences of skipping breakfast, and the overconsumption of soft drinks and screen media on abdominal obesity, overweight and obesity at follow-up. Adjustments were made for socio-economic (migration background, household income, and family education level) and individual (age and gender) variables, assignment to intervention or control

group of the underlying program evaluation, and school. Skipping breakfast and the overconsumption of screen media were more highly associated with abdominal obesity (odds ratio 3.36 and 2.46, respectively). Children who skipped breakfast and those who overconsumed screen media at baseline were more likely to be overweight at follow up (odds ratio 2.30 and 2.28, respectively).

Missing data

Children whose records contained missing data were significantly more likely to have a history of migration in their backgrounds, and were significantly more likely to be overweight, obese, or abdominally obese than children whose records contained complete data. On average, children whose records had missing data weighed less than children whose records contained complete data. Children whose records had missing data were more often living in single-parent homes and were more often in homes with a household income less than

Table 3 Generalised linear mixed regression model for abdominal obesity, overweight and obesity at follow-up

	Missing Values	Unadjusted		Adjusted*		
		OR	95% CI	OR	95% CI	p-value
Abdominal obesity						
				(n = 1253)		
Skipping breakfast	196	3.36	(2.23; 5.07)	2.06	(1.23; 3.47)	0.006**
Soft drinks > 1 time per week	198	1.78	(1.22; 2.61)	1.46	(0.92; 2.32)	0.108
Screen media > 1 h/day	1	2.46	(1.76; 3.45)	2.00	(1.23; 3.23)	0.005**
Overweight						
				(n = 1251)		
Skipping breakfast	201	2.30	(1.54; 3.45)	1.71	(1.04; 2.80)	0.034*
Soft drinks > 1 time per week	203	1.65	(1.16; 2.35)	1.29	(0.84; 1.96)	0.246
Screen media > 1 h/day	6	2.28	(1.67; 3.13)	2.01	(1.33; 3.03)	0.001***
Obesity						
				(n = 1251)		
Skipping breakfast	201	1.81	(0.94; 3.47)	0.90	[0.39; 2.07]	0.799
Soft drinks > 1 time per week	203	1.80	(1.04; 3.11)	1.57	(0.82; 3.03)	0.177
Screen media > 1 h/day	6	2.16	(1.34; 3.49)	1.87	(0.96; 3.67)	0.068

* adjusted for school, migration background, family education level, household income, age, gender, participation in the intervention, OR Odds Ratio, CI Confidence Interval

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

or equal to €1750. Furthermore, children whose records lacked complete data were less likely to live in a home with a tertiary family education level and were less likely to have been breastfed than were children whose records were complete. Moreover, children whose records had missing data spent more time with a PC on school days and were more likely to skip breakfast than their counterparts.

A sensitivity analysis was added to investigate possible differences between complete case analysis and analysis of datasets comprising multiple imputations. The results are shown in Table 4.

Discussion

This study shows that children skipping breakfast experience increased changes in WHtR, weight and BMI measures. Skipping breakfast and the overconsumption of screen media at baseline contributed to abdominal obesity at follow-up. Skipping breakfast and the overconsumption of screen media also influenced overweight at follow-up. No significant associations were found for the consumption of soft drinks with longitudinal weight development or weight status at follow-up.

Obesity and abdominal obesity

Children participating in the present study were identified to be abdominally obese according to the threshold of WHtR ≥ 0.5 . From these children, 18% were of normal weight, based on the BMI definition. This is in line with recent research literature saying that a considerable number of people are of normal or low weight according to the BMI definition, but are abdominally obese with a

higher risk of mortality [30, 31]. For children, rising numbers of abdominal obesity were detected, while rates of overweight and obesity, defined by BMI, seemed to stabilize, thus underestimating changes in weight development [32]. These results correspond with data which show that BMI fails to identify obesity in more than a quarter of children [33]. While BMI measures the general body structure as relative weight for height, WHtR provides information about body fat distribution.

To our knowledge, the majority of studies examine selected parameters, e.g. the association of skipping breakfast, or soft drink consumption or screen media consumption with predominantly one weight parameter, mostly BMI. The present study considers the influence of these critical behaviours on the longitudinal development in WHtR, weight and BMI measures and the presence of abdominal obesity, obesity and overweight at follow-up. Due to the short observation period of one year, and because of the rather gradual development of obesity, results were not as clearly significant as expected, especially for obesity at follow-up. Furthermore, yet not statistically significant, the intervention may have influenced the results. Another reason may be the relatively small number of obese children at follow-up that inhibits proof of significance. Therefore, longer observation periods are necessary to detect further associations.

Skipping breakfast

Results of the present study are consistent with previous research. Eating behaviours such as consuming unhealthy food or skipping breakfast in children have been

Table 4 Differences between analyses with datasets containing complete data (CD) and imputed data (ID)

		Skipping breakfast		Soft drinks > 1 time per week		Screen media > 1 h/day	
		OR	95% CI	OR	95% CI	OR	95% CI
Abdominal obesity	CD	2.06	(1.23; 3.47)**	1.46	(0.92; 2.32)	2.00	(1.23; 3.23)**
	ID	1.87	(1.19; 2.96)**	1.37	(0.92; 2.04)	1.81	(1.19; 2.75)**
Overweight	CD	1.71	(1.04; 2.80)*	1.29	(0.84; 1.96)	2.01	(1.33; 3.03)***
	ID	1.60	(1.02; 2.50)*	1.38	(0.94; 2.01)	1.76	(1.18; 2.61)**
Obesity	CD	0.90	(0.39; 2.07)	1.57	(0.82; 3.03)	1.87	(0.96; 3.67)
	ID	1.02	(0.50; 2.07)	1.56	(0.87; 2.80)	1.65	(0.90; 3.01)
		<i>B</i> (SE)	<i>p</i> -value	<i>B</i> (SE)	<i>p</i> -value	<i>B</i> (SE)	<i>p</i> -value
Changes in WHtR ^{a,b,c}	CD	0.50 (0.19)	0.007**	-0.01 (0.15)	0.966	0.29 (0.16)	0.074
	ID	0.51 (0.17)	0.003**	-0.07 (0.13)	0.600	0.17 (0.15)	0.240
Changes in weight [kg] ^{b,d}	CD	0.39 (0.12)	0.001***	-0.08 (0.09)	0.385	0.19 (0.10)	0.054
	ID	0.51 (0.17)	0.003**	-0.07 (0.13)	0.600	0.17 (0.15)	0.240
Changes in BMI percentiles ^{b,e}	CD	2.01 (0.90)	0.027*	-0.75 (0.70)	0.282	0.70 (0.78)	0.373
	ID	2.58 (0.83)	0.002**	-1.12 (0.64)	0.083	0.21 (0.72)	0.780

OR odds ratio, CI confidence interval, *B* (SE) *B* regression coefficient (standard error), ^a multiplied by 10² for better interpretability, ^badjusted for school, migration background, family education level, household income, age, gender, participation in the intervention, and ^cbaseline WHtR, ^dbaseline weight, ^ebaseline BMI percentiles
 *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

reported to be associated with higher odds for overweight [34]. A recent study showed that skipping breakfast was one modifiable factor for developing abdominal obesity in primary schoolchildren [27]. In a study with overweight Latino youth, Alexander et al. reported that higher visceral adiposity was associated with skipping breakfast [35].

Screen media consumption

Chaput et al. show that sedentary behaviour is associated with higher BMI, weight gain, and obesity in children [36]. Children's usage time of computers or TVs is increasing, and is associated with adverse health outcomes such as overweight or obesity [37]. Moreover, children having a TV in their bedroom are more likely to have sleep problems and long-term negative consequences on their health [38]. In our study it can be supposed that the identified effects intensify if enlarging the observational period, and children grow older. A study of American schoolchildren found that children who had screen media times of ≥ 2 h/day had double the odds of being overweight than do children with < 2 h/day [37]. In the present study, we were able to show that already > 1 h/day screen time is sufficient for having at least twice the odds for becoming overweight or abdominally obese.

Soft drink consumption

In general literature, there is no doubt about the positive association between soft drinks and overweight in children [13–15]. However, no significant association between soft drink consumption and weight development was found in the present study, this may be due to the young age of the children and the generally low consumption of soft drinks in this sample. In preschool children, Newby et al. also found no association between soft drink consumption and changes in weight and BMI [39]. They speculate that the low intakes and limited variations of soft drink consumption limited the results [39]. Low intakes could also be one reason for not finding significant results in the present study, as in primary schools vending machines are not as widespread as in secondary schools and the availability, and thus the consumption of soft drinks, is automatically reduced. Additionally, providing water to children in primary schools is widespread. Besides, Baden-Württemberg is a wealthy federal state with lower rates of social inequality and overweight than other parts of the country. Another reason possibly lies in the way soft drink consumption was assessed, and parents may have replied to the questionnaire in a socially desired manner. The questionnaire did not give information about the frequency of consumption of fruit nectars and of flavoured or chocolate milk drinks that contain high amounts of added sugar.

Overall, soft drink consumption was very limited in this sample.

Implications for families, future interventions and decision makers

Accordingly, interventions influencing positive weight status in schoolchildren have to include lifestyle patterns, such as having regular breakfast, and a responsible consumption of screen media and soft drinks. First of all, parents should be informed about the advantages and importance of a healthy lifestyle, and health-conscious behaviour. Second, institutions such as schools should be involved in the behaviour change. Finally, for obesity prevention, policy makers have to note that healthy eating and lifestyle habits are required at all times, but the cornerstone has to be laid early.

Parents who demonstrate and offer their children healthy and regular breakfast habits fulfil their function as role models. At institutional level, schools that ensure daily breakfast consumption at the start of the school day will reach all children and avoid the problem of skipping breakfast [40]. On a political level, the time of the start of school day should be discussed: A later start of classes might allow families to have breakfast together.

One possible idea for the prevention of overconsumption of screen media is to define determined times of the day for playing computer games or watching TV that regulate the duration of daily media consumption, e.g. in the form of an agreement between parents and children [41]. At all times, health-promoting programmes should offer and enhance various options against using screen media for schoolchildren. Thus, children's decision making-ability will be strengthened and children will learn and internalize a healthy lifestyle for permanent appropriation [42]. Times of sedentary behaviour are to be replaced with active and meaningful leisure activities.

One promising approach in the reduction of soft drink consumption is being practised via schools. The removal of soft drink vending machines limits the availability of these drinks as well as limiting their consumption by children [43]. One possibility is the installation of water dispensers in schools, or offering water or unsweetened tea for free in classrooms. Furthermore, in primary school, children's parents should be involved: The regular provision of water, organized by parents, constitutes a suitable measurement for changing the environment.

Strengths and limitations

This study provides valuable insights into the connection between skipping breakfast, soft drink and screen media consumption with weight development in schoolchildren. There are some strengths and limitations that should be taken into consideration when interpreting

these results. One strength of this research is the strict protocol of a longitudinal trial. A second strength is the large sample size and the fact that the study includes data from an entire state of Germany, although the study is not representative for the whole of Germany. All anthropometric data were objectively measured by trained staff in a standardized procedure and are of high quality. Furthermore, the Institute of Epidemiology and Medical Biometry at Ulm University managed data professionally, and advised in statistical issues. Finally, to our knowledge, this the first study to specifically investigate these three weight-influencing parameters in primary schoolchildren in combination. However, there are also some limitations: First, the observational character of the study may have led to some biased results. Due to the young age of the children, parental report measures were used to assess health and lifestyle characteristics, and some of the questions might have been answered in a socially desired way or show the Hawthorne effect, which describes that participants in observational studies behave differently. Moreover, the investigated variables on children's weight development could have been complemented by chronobiological aspects. Information on the children's sleep was not collected, but may also be relevant for their health [44]. As far as school schedules as a further influencing factor on chronobiological aspects are concerned, the included primary schools started between half past seven and eight o'clock and included one or two break times per morning. At the time of the assessment in 2010, all-day school was not yet very common in primary schools in Baden-Württemberg, so most children went home after school at noon.

Furthermore, participation in this study was voluntary and only teachers and parents who gave their agreement were included. Thus, it seems reasonable that teachers and parents who were motivated and health conscious were more likely to take part. Parental breakfast and soft drink intake were not assessed in the present investigation, but in future research these parameters should be included. Another problem of observational studies are missing values which may, in the worst case lead to biased results [26]. Therefore, a missing data analysis and additionally a sensitivity analysis with imputed data were performed. The latter confirmed the significance of the investigated influence of skipping breakfast and screen media use on weight development.

Conclusion

Soft drink consumption was not associated with weight status in this sample, but should be investigated in more detail in future research. The skipping of breakfast and the overconsumption of screen media influence weight development in primary schoolchildren. Dietary improvements

and restriction in screen times are promising approaches in obesity prevention in schoolchildren. Especially with regard to the high prevalence of overweight and abdominal obesity in parents, healthy breakfast habits both at home or in schools and an awareness of screen media consumption may not only improve children's health but that of their parents, too. Children, parents, schools and governments should be involved in behavioural and structural prevention. Finally, further research should examine the combined effects of these crucial variables on weight development for a longer period, at least over the period of four school years in primary school.

Abbreviations

BMI: Body mass index; CASMIN classification: Comparative Analysis of Social Mobility in Industrial Nations; DRKS: German Clinical Trials Register; ISAK: International Standards for Anthropometric Assessment; KiGGS survey: German Health Interview and Examination Survey for Children and Adolescents; NCD: Non-communicable diseases; OR: Odds ratio; WC: Waist circumference; WHO: World Health Organization; WHtR: Waist-to-height ratio

Acknowledgments

Thanks to Ileana Briegel, Jens Dreyhaupt, Eva-Maria Friedemann, Anne Kelso, Lina Hermeling, Eleana Georgiou, Ekaterine Goosmann, Christine Lämmle, Rainer Muche, Olga Pollatos, Luise Steeb, Belinda Hoffmann, Susanne Kobel, Tamara Wirt of the "Join the Healthy Boat – primary school" research group for their input. Most of all, we thank the teachers, pupils and their parents who participated in the Baden-Württemberg Study. Finally, we thank Sinéad McLaughlin for her language assistance.

Funding

The programme "Join the Healthy Boat – primary school" is financed by the Baden-Württemberg Stiftung. The Baden-Württemberg Stiftung had no influence on the content of the manuscript.

Availability of data and materials

The datasets generated and analysed during the current study are not publicly available due to reasons of data protection but are available from the Institute of Epidemiology and Medical Biometry, Ulm University, on reasonable request.

Authors' contributions

DK, OW and other members of the research group planned and organized the Baden-Württemberg study. DK and other members of the research group were involved in carrying out the measurements. MT and DK performed the statistical analyses. JMS is the director of the programme "Join the Healthy Boat – primary school" and principal investigator of the Baden-Württemberg Study. MT, RL, and DK drafted the manuscript. TK, OW and JMS revised the manuscript drafts. All authors have read and approved the final version of the manuscript.

Ethics approval and consent to participate

The study protocol was approved by the ethics committee of Ulm University in June 2009 (Application No. 126/10). The Baden-Württemberg Study is registered at the German Clinical Trials Register (DRKS) under the DRKS-ID: DRKS00000494. Written informed consent was obtained from parents and teachers.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Author details

¹Medical Center, Division of Sports and Rehabilitation Medicine, University of Ulm, Frauensteige 6, Haus 58/33, 89075 Ulm, Germany. ²Institute of General Medicine, Ulm University, 89081 Ulm, Germany. ³Department of Computer Science, Ulm University of Applied Sciences, 89081 Ulm, Germany. ⁴Institute of Medical Systems Biology, Ulm University, 89081 Ulm, Germany.

Received: 13 November 2017 Accepted: 6 March 2018

Published online: 16 March 2018

References

- Pigeot I, Buck C, Herrmann D, Ahrens W. Übergewicht und Adipositas bei Kindern und Jugendlichen. Die weltweite Situation [Overweight and obesity in children and adolescents. The worldwide situation]. Bundesgesundheitsblatt Gesundheitsforsch Gesundheitsschutz. 2010;53(7): 653–65.
- World Health Organisation. The world health report 2002: Reducing risk, Promoting healthy life. WHO Press. 2002. http://www.who.int/whr/2002/en/whr02_en.pdf?ua=1. Accessed 17 Oct 2017.
- Daniels S. Complications of obesity in children and adolescents. Int J Obes. 2009;33:60–5.
- Bloom DE, Cafiero E, Jané-Llopis E, Abrahams-Gessel S, Reddy Bloom L, Fathima S, et al. The global economic burden of Noncommunicable diseases. 2011. <http://apps.who.int/medicinedocs/documents/s18806en/s18806en.pdf>. Accessed 17 Oct 2017.
- Hainer V, Aldhoon-Hainerova I. Obesity paradox does exist. Diabetes Care. 2013;36(Suppl 2):S276–S281.
- Steele RM, Van Sluijs EMF, Cassidy A, Griffin SJ, Ekelund U. Targeting sedentary time or moderate- and vigorous-intensity activity: independent relations with adiposity in a population-based sample of 10-y-old British children. Am J Clin Nutr. 2009;90:1185–92.
- Funk MB, Bausback-Schomakers S, Hanschmann KM, Gerhards B, Kuhn K, Krackhardt B. Gewichtsentwicklung im frühen Grundschulalter. Prävalenz, Inzidenz und Risikofaktoren für Übergewicht und Adipositas [Overweight in primary school-age children. Prevalence and risk factors]. Bundesgesundheitsblatt Gesundheitsforsch Gesundheitsschutz. 2015;58(10):1110–7.
- Szajewska H, Ruszczyński M. Systematic review demonstrating that breakfast consumption influences body weight outcomes in children and adolescents in Europe. Crit Rev Food Sci Nutr. 2010;50(2):113–9.
- de la Hunty A, Gibson S, Ashwell M. Does regular breakfast cereal consumption help children and adolescents stay slimmer? A systematic review and meta-analysis. Obes Facts. 2013;6(1):70–85.
- Rosiek A, Maciejewska NF, Leksowski K, Rosiek-Kryszewska A, Leksowski L. Effect of television on obesity and excess of weight and consequences of health. Int J Environ Res Public Health. 2015;12(8):9408–26.
- Krahnstoever Davison K, Marshall SJ, Birch LL. Cross-sectional and longitudinal associations between TV viewing and girls' body mass index, overweight status, and percentage of body fat. J Pediatr. 2006;149(1):32–7.
- Katzmarzyk P, Broyles S, Champagne C, Chaput J-P, Fogelholm M, Hu G, et al. Relationship between soft drink consumption and obesity in 9–11 years old children in a multi-national study. Nutrients. 2016;8(12):1–13.
- Bes-Rastrollo M, Sayon-Orea C, Ruiz-Canela M, Martinez-Gonzalez MA. Impact of sugars and sugar taxation on body weight control: a comprehensive literature review. Obesity. 2016;24(7):1410–26.
- Keller A, Bucher Della Torre S. Sugar-sweetened beverages and obesity among children and adolescents: a review of systematic literature reviews. Child Obes. 2015;11(4):338–46.
- Vos MB, Kaar JL, Welsh JA, van Horn LV, Feig DI, Anderson CAM, et al. Added sugars and cardiovascular disease risk in children: a scientific statement from the American heart Association. Circulation. 2016;134:1–32.
- Lee AK, Chowdhury R, Welsh JA. Sugars and adiposity: the long-term effects of consuming added and naturally occurring sugars in foods and in beverages. Obes Sci Pract. 2015;1(1):41–9.
- Dreyhaupt J, Koch B, Wirt T, Schreiber A, Brandstetter S, Kesztyues D, et al. Evaluation of a health promotion program in children: study protocol and design of the cluster-randomized Baden-Wuerttemberg primary school study. BMC Public Health. 2012;12(1):157.
- Brauns H, Steinmann S. Educational reform in France, West-Germany and the United Kingdom: updating the CASMIN educational classification. ZUMA Nachrichten. 1999;23:7–44.
- Lange M, Kamtsiuris P, Lange C, Schaffrath Rosario A, Stolzenberg H, Lampert T. Messung soziodemographischer Merkmale im Kinder- und Jugendgesundheitsurvey (KiGGS) und ihre Bedeutung am Beispiel der Einschätzung des allgemeinen Gesundheitszustands. Bundesgesundheitsblatt Gesundheitsforsch Gesundheitsschutz. 2007;50(5–6):578–89.
- Kurth B-M. Der Kinder- und Jugendgesundheitsurvey (KiGGS): Ein Überblick über Planung, Durchführung und Ergebnisse unter Berücksichtigung von Aspekten eines Qualitätsmanagements TL - 50. Bundesgesundheitsblatt Gesundheitsforsch Gesundheitsschutz. 2007;50(5/6):533–46.
- World Health Organization. Global recommendations on physical activity for health. Geneva. 2010. https://www.ncbi.nlm.nih.gov/books/NBK305057/pdf/Bookshelf_NBK305057.pdf. Accessed 17 Oct 2017.
- Stewart A, Marfell-Jones M, Olds T, De Ridder H. International standards for anthropometric assessment. In: International Standards for Anthropometric Assessment. International Society for the Advancement of Kinanthropometry. 2011. <http://www.ceap.br/material/MAT17032011184632.pdf>. Accessed 17 Oct 2017.
- Kromeyer-Hauschild K, Wabitsch M, Kunze D, Geller F, Geiß HC, Hesse V, et al. Perzentile für den Body-mass- Index für das Kindes- und Jugend- alter unter Heranziehung verschiedener deutscher Stichproben [Percentiles of bodymass index in children and adolescents evaluated from different regional German studies]. Monatsschrift Kinderheilkd. 2001;149:807–18.
- Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. Int J Food Sci Nutr. 2005;56(5):303–7.
- World Health Organisation. Physical status: the use and interpretation of anthropometry. In: Report of a WHO Expert Committee. WHO Technical Report Series 854. 1995. http://apps.who.int/iris/bitstream/10665/37003/1/WHO_TRS_854.pdf. Accessed 17 Oct 2017.
- Vandenbroucke JP, Von Elm E, Altman DG, Gøtzsche PC, Mulrow CD, Pocock SJ, et al. Strengthening the reporting of observational studies in epidemiology (STROBE): explanation and elaboration. PLoS Med. 2007;4(10):1628–54.
- Kesztyüs D, Traub M, Lauer R, Kesztyüs T, Steinacker JM. Correlates of longitudinal changes in the waist-to-height ratio of primary school children: implications for prevention. Prev Med Reports. 2016;3:1–6.
- Kesztyüs D, Lauer R, Kesztyüs T, Kilian R, Steinacker JM. Costs and effects of a state-wide health promotion program in primary schools in Germany - the Baden-Württemberg study: a cluster-randomized, controlled trial. PLoS One. 2017;12(2):1–18.
- Holm S. A simple sequentially Rejective multiple test procedure. Scand J Stat. 1979;6(2):65–70.
- Coutinho T, Goel K, Corrêa De Sá D, Carter RE, Hodge DO, Kragelund C, et al. Combining body mass index with measures of central obesity in the assessment of mortality in subjects with coronary disease: role of "normal weight central obesity". J Am Coll Cardiol. 2013;61(5):553–60.
- Pischon T, Boeing H, Hoffmann K, Bergmann M, Schulze M, Overvad K, et al. General and abdominal adiposity and risk of death in Europe. N Engl J Med. 2008;359(20):2105–20.
- Griffiths C, Gately P, Marchant PR, Cooke CB. A five year longitudinal study investigating the prevalence of childhood obesity: comparison of BMI and waist circumference. Public Health. 2013;127(12):1090–6.
- Javed A, Jumeau M, Murad MH, Okorodudu D, Kumar S, Somers VK, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents. Pediatr Obes. 2015;10(3):234–44.
- Brug J, Van Stralen MM, te Velde SJ, Chinapaw MJM, De Bourdeaudhuij I, Lien N, et al. Differences in weight status and energy-balance related behaviors among schoolchildren across Europe : the ENERGY-project. PLoS One. 2012;7(4):1–13.
- Alexander KE, Ventura EE, Spruijt-Metz D, Weigensberg MJ, Goran MI, Davis JN. Indices in overweight Latino youth. Obesity. 2010;17(8):1528–33.
- Chaput J-P, Leduc G, Boyer C, Belanger P, LeBlanc A, Borghese M, et al. Objectively measured physical activity , sedentary time and sleep duration: independent and combined associations with adiposity in Canadian children. Nutr Diabetes. 2014;4:1–5.
- Steffen LM, Dai S, Fulton JE, Labarthe DR. Overweight in children and adolescents associated with TV viewing and parental weight: project HeartBeat! Am J Prev Med. 2009;37(Suppl 1):1–12.
- Garrison MM, Liekweg K, Christakis D. Media use and child Sleep : the impact of content , timing , and environment. Pediatrics. 2011;128(1):29–35.
- Newby PK, Peterson KE, Berkey CS, Leppert J, Willett WC, Colditz GA. Beverage consumption is not associated with changes in weight and body

- mass index among low-income preschool children in North Dakota. *J Am Diet Assoc.* 2004;104(7):1086–94.
40. Kesztyüs D, Traub M, Lauer R, Kesztyüs T, Steinacker JM. Skipping breakfast is detrimental for primary school children: cross-sectional analysis of determinants for targeted prevention. *BMC Public Health BMC Public Health.* 2017;17(1):258.
 41. Beck A, Eichner M. Empfehlungen für jedes Alter – gegen den Sitzenden Lebensstil von Kindern. *B&G Bewegungstherapie und Gesundheitssport.* 2014;30(3):113–4.
 42. Seufert T, Muche R, Steinacker JM. Gesundheitsförderung in der Grundschule. *Komm mit in das gesunde Boot-Grundschule. Schriftenreihe der Baden Württemberg Stiftung.* 2012;63:1–61.
 43. Welsh JA, Lundeen EA, Stein AD. The sugar-sweetened beverage wars: public health and the role of the beverage industry. *Curr Opin Endocrinol Diabetes Obes.* 2013;20(5):401–6.
 44. Carissimi A, Dresch F, Martins A, Levandovski RM, Adan A, Natale V, et al. The influence of school time on sleep patterns of children and adolescents. *Sleep Med.* 2016;19:33–9.

Submit your next manuscript to BioMed Central and we will help you at every step:

- We accept pre-submission inquiries
- Our selector tool helps you to find the most relevant journal
- We provide round the clock customer support
- Convenient online submission
- Thorough peer review
- Inclusion in PubMed and all major indexing services
- Maximum visibility for your research

Submit your manuscript at
www.biomedcentral.com/submit

