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Investigating the influence of physical activity composition on arterial stiffness in youth

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ABSTRACT

Physical activity is beneficial for arterial health in children but less is known about how all daily movement behaviours influence arterial stiffening. Compositional analysis can account for the co-dependent nature of these behaviours and therefore was employed to explore how the movement composition influences arterial health. Augmentation index (AIx) and pulse wave velocity were measured cross-sectionally in healthy children (n = 129; 12.4 ± 1.6 years). Time spent in sedentary, light physical activity (LPA), moderate-to-vigorous physical activity (MVPA) and asleep were derived from seven-day hip-worn accelerometry. The relative effects of individual behaviours and the overall movement composition on arterial stiffness were explored utilising compositional analysis, with predictive modelling used to predict effects of the substituting time between behaviours. Girls (n = 45, 12.1 ± 1.5yrs, 20.5 ± 3.6kg·m^{-2}) had a higher AIx (+ 3.94; $p < 0.05$) and accrued physical activity predominantly in LPA, whereas boys (n = 56, 12.6 ± 1.7yrs, 20.6 ± 4.0kg·m¯2) accrued physical activity predominantly in MVPA. Individual behaviours and the movement composition were not significant predictors of any measure of arterial stiffness ($P > 0.05$), and the reallocation of 20-minutes between behaviours did not elicit significant change in arterial stiffness, irrespective of sex ($P > 0.05$). The reallocation of time to MVPA from any other behaviour did not predict an improvement in arterial stiffness. This highlights the high potential dose of MVPA required to improve arterial health and the complex nature of the determinants of arterial stiffness.

Highlights

- Movement behaviours in isolation nor combination predicted arterial stiffness in youth.
- The reallocation of behaviours from any other behaviour to MVPA did not affect arterial stiffness in youth.
- Arterial stiffness is a complex, multidimensional health parameter that does not appear to be primarily determined by physical activity levels or intensity.

KEYWORDS
Compositional analysis; sedentary; sleep; pulse wave velocity; children; adolescents

1. Introduction

Paediatric health research has largely focused on the effects of physical activity and sedentary time in isolation, often covarying for the remaining behaviours (Carson & Janssen, 2011; Colley, Garriguet, Janssen, & Wong, 2013; Warburton, Nicol, & Bredin, 2006). However, the inherently co-dependent nature of movement behaviours violates the assumptions of independence in most traditional statistical methods (Carson, Tremblay, Chaput, & Chastin, 2016; Chastin, Palarea-Albaladejo, Dontje, & Skelton, 2015). The use of compositional analysis, which has the ability to account for co-dependency between daily movements, can facilitate a greater understanding by exploring associations relative to the remaining behaviours in a given time period, such as a day (Chastin et al., 2015). Moreover, compositional analysis can identify potential interventional targets and reveal potentially "optimal" compositions for health (Chastin et al., 2015).

The individual effects of physical activity and sedentary time on cardiovascular risk factors are well researched in youth, with suggestions that physical activity and sedentary time act independently and in an opposing manner on cardiovascular health (Froberg & Andersen, 2005; Kohl, 2001; Vasankari et al., 2017). In particular, arterial stiffness, a pre-clinical risk marker for cardiovascular disease CVD; (Cheung, 2010; Savant, Furth, & Meyers, 2014), is positively influenced by physical activity (Edwards et al., 2012; Sakuragi et al., 2009), but negatively by sedentary time (Haapala et al., 2017;

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Nettlefold, McKay, Naylor, Bredin, & Warburton, 2019). Arterial stiffness progresses naturally with age, but prolonged periods of sedentary time have been shown to result in a premature progression and subsequent increases in the risk of developing CVD (Cote et al., 2015; Nettlefold et al., 2019; Veijalainen et al., 2016). Conversely, a beneficial relationship between physical activity and arterial health is evident, with active children demonstrating less stiffening with age compared to more inactive and sedentary counterparts (Edwards et al., 2012; Haapala et al., 2017; Ried-Larsen et al., 2014; Veijalainen et al., 2016).

Differences in physical activity behaviours between sexes have been observed, resulting in differing compositions of movement behaviours according to sex (Gordon-Larsen, McMurray, & Popkin, 2000; Olds et al., 2009). Specifically, prepubescent girls and boys engage in similar levels of total physical activity but pubertal girls typically demonstrate greater volumes of light physical activity (LPA) and less moderate-to-vigorous physical activity (MVPA) than their male counterparts (Dumith, Gigante, Domingues, & Kohl, 2011). These differences in movement behaviours, and the rate of decline in the volume and intensity of physical activity according to sex, may subsequently influence arterial stiffening and possibly increase the risk of premature CVD. Indeed, in young children, girls have less compliant and stiffer arteries than boys, although this difference may be ameliorated during puberty (Ahimastos, Formosa, Dart, & Kingwell, 2003; Rossi, Francès, Kingwell, & Ahimastos, 2011; Stoner, Faulkner, Westrupp, & Lambrick, 2015).

Whilst the effects of physical activity and sedentary time on markers of arterial health have been explored in isolation, few studies have utilised compositional analysis to investigate the relative influence of movement behaviours within a day. Carson et al. (2016) investigated the effects on cardiometabolic risk factors, reporting an increased MVPA, relative to remaining behaviours, to be associated with a decreased body mass index (BMI) and waist circumference in children. However, equivocal findings have been reported regarding the relative influence of sedentary time, LPA and sleep on cardiometabolic risk (Stefelová et al., 2018). These ambiguous findings may be a consequence of a number of inter-study differences, including the health measures considered, the study population characteristics and/or to the accelerometer data-processing decisions. As a result, further research is warranted to better understand the relative influences of movement behaviours on cardiometabolic health.

The primary aim of the present study was therefore to explore the relative effects of daily movement behaviours on markers of arterial stiffness in children and adolescents. Secondary aims were to ascertain whether differences in physical activity composition according to sex influenced these arterial markers and the influence of reallocating time between behaviours on health outcomes.

2. Methods

In total, 129 children and adolescents (girls: 12.0 ± 1.4 yrs, 1.52 ± 0.09 m; 48.5 ± 12.5 kg; 20.8 ± 4.6 kg·m^{-2}; boys: 12.6 ± 1.6 yrs, 1.58 ± 0.14 m; 53.7 ± 15.2 kg; 21.3 ± 4.4 kg·m^{-2}), recruited via convenience sampling from schools in South Wales, participated in this cross-sectional study. This study was approved by the institutional research ethics committee, with all procedures completed in accordance with the Declaration of Helsinki. Prior to data collection, written informed consent and assent were obtained from parents/guardians and participants, respectively. The key inclusion criterion was being aged 8–16 years, while exclusion criteria included any known hypertensive, metabolic or cardiovascular condition that could influence assessment of vascular health.

2.1 Anthropometrics

Stature, sitting stature and body mass were measured to the nearest 0.01, 0.01 m and 0.1 kg using a portable standing stadiometer (Seca 213, Seca, Chino, CA, USA), sitting stadiometer (Holtain Ltd, Crymych, Pembrokeshire, Wales) and electronic scales (Seca 803, Seca, Chino, CA, USA), respectively. BMI was subsequently calculated and maturity was estimated using sex-specific maturity offset equations to predict time from peak height velocity PHV; (Mirwald, Baxter-Jones, Bailey, & Beunen, 2002). Participants were classified into three stages relative to PHV: pre-PHV if more than one year pre-PHV, circa-PHV if less than one year pre- or post-PHV, and post-PHV if more than one year post-PHV (Mirwald et al., 2002).

2.2 Arterial stiffness

Arterial stiffness was non-invasively assessed using an osillometric device (Vicorder, Skidmore Medical, Bristol, UK) and accompanying blood pressure cuffs (D. E. Hokanson Inc, Bellevue, WA, USA). Measurements were completed with the participant in the supine position with the torso elevated to 30°, in a quiet environment and after a five-minute resting period to ensure stable haemodynamics. Indirect central arterial stiffness was estimated with a cuff placed over the brachial artery on the upper left arm, with blood pressure taken a minimum of two times via an inbuilt automated function. Pulse pressure (PP) and augmentation index (AIx) were derived from the PP waveform recording, with AIx derived as augmented pressure expressed as a percentage of PP (Wilkinson et al., 2000). Stiffness was assessed with a partial cuff placed over the carotid artery and a brachial cuff over the femoral artery. The sum of the distance between the sternal notch and umbilicus and the umbilicus to the middle of the femoral cuff was measured, with PWV, in m·sec^{-1}, subsequently derived according to the time between carotid and femoral pulse waves. Each assessment was completed a minimum of three times to obtain at least two congruent measures within 5 mmHg, 5% or 0.5 m·sec^{-1} of each other for pulse pressure, AIx and PWV, respectively.

2.3 Physical activity

Participants were asked to wear an ActiGraph GT3X+ accelerometer (ActiGraph, Pensacola, Florida, USA), sampling at 100 Hz, on the right hip for seven-consecutive days. Furthermore, participants were asked to complete wear-time and sleep diaries, to record monitor removal and the duration and perceived quality of sleep. Accelerometry data was downloaded, integrated to 15s epochs and analysed using ActiLife v6.13.4 software (ActiGraph, Pensacola, Florida, USA). Participants were required to meet a wear-time of ≥ 10 h on any three days in order to be included in the analyses (Fairclough et al., 2016). Evenson, Catellier, Gill, Ondrak, and McMurray (2008) physical activity cut-points, identified as the most appropriate cut-points to give a reliable representation of light, moderate and vigorous intensity physical activities, were used.

2.4 Statistical analysis

Initial statistical analyses were performed using IBM SPSS software package for Macintosh (Version 22.0, IBM, Portsmouth, UK), with significance set as $p < 0.05$ and all data expressed as mean ± standard deviation (SD), unless stated otherwise. A one-way ANOVA was used to establish any significant differences in arterial stiffness measures or movement behaviours according to sex.

Table 1. Participant descriptives and arterial stiffness according to sex.

	Girls (*n* = 45)	Boys (*n* = 56)
Age (years)	12.1 ± 1.5	12.6 ± 1.7
Maturity offset	−0.30 ± 0.80*	−1.16 ± 1.76
Height (m)	1.52 ± 0.09*	1.58 ± 0.14
Mass (kg)	47.9 ± 11.0*	52.2 ± 6.415.3
BMI (kg·m^{-2})	20.5 ± 3.6	20.6 ± 4.0
PP (mmHg)	60 ± 8	60 ± 10
AIx (%)	11.9 ± 5.2*	10.4 ± 5.5
MAP (mmHg)	78 ± 7	76 ± 7
PWV (m·sec^{-1})	4.92 ± 0.55	4.97 ± 0.60

Data is presented as mean ± SD. Body mass index (BMI), pulse pressure (PP), augmentation index (AIx), mean arterial pressure (MAP), pulse wave velocity (PWV). * Significant differences according to sex.

The Compositions package Version 1.40-2; (Chastin et al., 2015), and its dependencies, in R (http://cran.r-project.org) were used to conduct compositional analysis. For all participants, time in each movement behaviour (i.e. sedentary time, LPA, MVPA and sleep) was normalised as a proportion of the total time in all behaviours, with the geometric means and the variation matrix then calculated for each behaviour and grouping (Chastin et al., 2015). A log contrast between each movement behaviour, the geometric mean for the whole sample and the mean of each subgroup was subsequently calculated. Next, the relative distribution of physical activity behaviours and the effects on arterial stiffness measures were examined by transforming to isometric log-ratios (ILR) of time, equalling a total of one, and producing sequential compositional linear regression models for each stiffness measure, covarying for sex and weight status. The initial coefficient and *p*-value for each sequential model were taken as the direction of effect and significance of the ILR analysis for each health outcome (Carson et al., 2016). A *p*-value of ≤ 0.05 was chosen to reflect statistical significance in line with statistical convention, however given the small sample size, generalisation the results should be made with caution. Predictive change models to examine the effect of displacing time from one behaviour to another (e.g. displacing 20 min of sedentary time to MVPA) on arterial stiffness measures were produced based on the initial compositions for sex. Specifically, each predictive model back-transformed the previous ILR behaviour co-ordinates to determine the effect based on the average composition for each grouping and expressed as the percentage change in the outcome parameter, around the group mean (Chastin et al., 2015). The predicted percentage change in each measure was then compared against the percentage smallest worthwhile change (SWC%) to identify a meaningful and significant change. The SWC% was calculated for the group mean of each arterial measure to represent the minimally clinically important difference MCID; (Wells et al., 2001).

3. Results

The final sample consisted of 101 participants following the exclusion of 28 participants who failed to meet the wear-time criteria, with no significant differences between those included and excluded. Boys were taller (1.58 ± 0.14 vs. 1.52 ± 0.09 m; $F_{(1,\ 98)} = 3.91$, $p \leq 0.05$), heavier (52.2 ± 6.4 vs. 47.9 ± 11.1 kg; $F_{(1,\ 98)} = 5.41$, $p \leq 0.05$), less mature (-1.16 ± 1.76 vs. -0.30 ± 0.80 yrs; $F_{(1,\ 98)} = 8.61$, $p \leq 0.01$), and had a lower AIx (10.4 ± 5.5 vs. 11.9 ± 5.2%; $F_{(1,\ 98)} = 3.94$, $p \leq 0.05$) than their female counterparts (Table 1).

Overall, participants spent waking hours in predominantly sedentary pursuits, with physical activity only accounting for 17.2% of this time (Table 2). Sleep and sedentary time (0.014), and sedentary time and LPA (−0.017), demonstrated the smallest pair-wise log variances, suggesting higher levels of co-dependence. In contrast, MVPA showed the highest log-ratio variance with all other movement behaviours (Sed 0.054; LPA −0.122; Sleep −0.037) and therefore the least co-dependency. Moreover, MVPA was found to explain 67% of log-ratio variance, with LPA accounting for 26% and the remaining 7% explained by sedentary time and sleep. Comparison of geometric means by sex indicated that girls accrued a similar volume of sedentary time, a greater volume of LPA and less time in MVPA and sleep relative to boys.

The overall movement behaviour composition for the whole sample, as demonstrated by the model *p*-value, was not significantly associated with any arterial measure (Table 3). According to the ternary heat maps (Supplementary Figure 1), the relative influences of MVPA and sedentary time indicate that a high MVPA and low sedentary time result in a more favourable aPWV in girls. In contrast, in boys, the relative influences of movement behaviours on aPWV are less clear but suggest moderate-to-low sedentary time (Supplementary Figure 1) and moderate-to-high LPA and MVPA predict a more favourable aPWV.

No significant percentage changes were present in any cardiovascular measures with the reallocation of 20 min from one behaviour to any other (Table 4). The non-significant predictive changes with reallocation of time were predominantly symmetrical, except for substituting time between sedentary and MVPA for PP, irrespective of sex. While non-significant, the greatest increases in AIx and PWV were predicted with the reallocation of time from MVPA to sleep, and in AIx by substituting time in LPA to sleep. However, decreasing time from sleep to LPA resulted in a decreased AIx, irrespective of sex.

Table 2. Actual mean, geometric mean and percentage of 24 h for each movement behaviour and sleep for the whole sample.

	SED	LPA	MVPA	SLEEP
Mean (min·day^{-1})	510.9	192.9	30.4	470.9
Geometric Mean (min·day^{-1})	617.8	215.4	31.8	574.1
Percentage of 24 h (%)	42.9	15.0	2.2	39.9

Sedentary time (SED), light physical activity (LPA), moderate-to-vigorous physical activity (MVPA).

4. Discussion

This is the first study to employ compositional analysis to explore the combined effects of movement behaviours on arterial measures in a paediatric population. Overall, there was no significant effect of the mean physical activity composition on any cardiovascular measure, with the composition similar regardless of sex. Furthermore, predictive analysis found no significant effect on central stiffening with the reallocation of 20 min of MVPA to either sedentary time, LPA or sleep. Conversely, PWV was predicted to be non-significantly reduced for both groups with the substitution of time from sedentary, LPA and sleep to MVPA. Finally, the small sample size must be taken into consideration when interpreting the present findings due to the limitations in generalisability.

Previous studies have employed compositional analysis to explore the relative associations of movement behaviours with cardiometabolic health in both children (Carson et al., 2016) and adults (Chastin et al., 2015). However, to our knowledge, no study has explored the associations of these measures with arterial stiffening. Carson et al. (2016) reported that the overall movement composition was significantly associated with all cardiometabolic markers, though, when considered in isolation, only BMI and waist circumference were significantly predicted by all behaviours. In contrast, the present study found no significant relationships for the overall composition, or individual effects, of movement behaviours with markers of arterial stiffening. The lack of significant association suggests that movement composition alone does not explain all of the variance in the outcome, with additional confounding factors beyond age and sex effecting arterial stiffening. For example, cardiorespiratory fitness (CRF) has been shown to have a mediatory effect on the age-related progression of central stiffening (Ogola et al., 2018; Veijalainen et al., 2016), with lower CRF associated with premature stiffening in children (Sakuragi et al., 2009). Future studies should therefore explore the mediatory influence of CRF on the relationship between physical activity and arterial stiffness.

Compositional research, irrespective of population, indicates that the relative associations of movement behaviours do not necessarily emulate those of individual behaviours in isolation (Carson et al., 2016; Chastin et al., 2015). Specifically, negative correlations between sedentary time and cardiometabolic health were

Table 3. Compositional model of movement behaviours, sedentary time, LPA, MVPA and sleep, for each measure of arterial health in the overall sample, adjusted for age, maturity and sex.

	Model p	Model R^2	γ_{SED}	p	γ_{LPA}	p	γ_{MVPA}	p	γ_{SLEEP}	P
PP	0.27	0.01	−1.52	0.41	1.78	0.12	0.04	0.96	−0.03	0.88
Aix	0.57	−0.01	0.00	0.99	−0.83	0.22	−0.07	0.87	0.90	0.45
PWV	0.31	0.01	−0.08	0.51	0.04	0.60	−0.02	0.76	0.05	0.67

Sequential rotated isometric log-ratio (ILR) modelling for each arterial health measure, adjusted for age and sex. Sedentary time (SED), light physical activity (LPA), moderate-to-vigorous physical activity (MVPA), pulse pressure (PP), augmentation index (AIx), mean arterial pressure (MAP), and pulse wave velocity (PWV). Regression coefficients (γ) relate to the change in log-ratio for a given behaviour, relative to other behaviours.

identified in children, relative to remaining behaviours, whereas previous research utilising traditional analyses found sedentary time to have equivocal effects on such markers (Carson et al., 2016). In the current sample, sedentary time was not associated with AIx, but an increased time in sedentary pursuits trended towards decreases in PP and PWV. These indications are in contrast to previous research investigating the influence of sedentary time in isolation where greater time sedentary was consistently associated with an elevated arterial stiffening in children and adolescents (Haapala et al., 2017; Nettlefold et al., 2019). Whilst sedentary time has been demonstrated to act negatively on arterial health in isolation (Väistö et al., 2019), it could be postulated that inactivity may be a more important target to slow premature increases in CVD risk. Interestingly, higher levels of LPA showed a trend towards a greater decrease in AIx than observed with levels of MVPA. Conversely, a higher MVPA was not significantly associated with a decreased PWV, with the opposite observed with LPA. These findings are discordant with studies in adolescents (Edwards et al., 2012), overweight children (Sakuragi et al., 2009), and children with chronic health conditions (Wadwa et al., 2010), which found significant negative associations between MVPA and stiffness measures. Moreover, while evidence for the influence of LPA on stiffening is less established than MVPA, preliminary research indicates that greater volumes of LPA in adolescents are associated with a more favourable PWV (Edwards et al., 2012).

The non-significant effect of MVPA on vascular measures in the present sample may be a consequence of a number of factors, including differences in patterns of accumulation of sedentary time and LPA, and disparities in the spread of data for AIx and PWV. Specifically, girls accrued a greater volume of LPA, but less MVPA, with similar volumes of sedentary time and sleep, compared to boys. It could therefore be postulated that girls interrupted prolonged periods of sedentary time with periods of LPA. Alternatively, such findings could be due to the misclassification of sedentary time and LPA from accelerometer data due to the short monitoring period (Byrom, Stratton, McCarthy, & Muehlhausen, 2016). Conversely, the observed differences may, at least in part, be due to the differing spread of data between arterial measures, with the SD varying from 11% for PWV, to 44% for AIx in girls. Consequently, the differences in the magnitude of the relationship may inappropriately suggest a lesser influence of physical activity on vascular health. Indeed, the current findings indicate a minimal effect of MVPA, discordant with Väistö et al. (2019) who found LPA was more weakly associated with cardiometabolic health than MVPA. The lack of relationship between MVPA and vascular health in the present study compared to that found by Väistö et al. could be attributed to a large difference between the time spent in MVPA (30.4 v 116.0 mins/day, respectively) (Väistö et al., 2019), with the present sample accruing approximately half the recommended volume (UK Chief Medical Officer C, 2019). Nonetheless, taken together these findings provide further evidence that the intensity of physical activity is important for arterial health in paediatric populations (Germano-Soares et al., 2018).

Reducing time in MVPA by 20-minutes and increasing sedentary time, LPA or sleep, whilst not significant, consistently predicted negative effects on arterial stiffening. These findings may highlight the importance of MVPA for the maintenance of vascular health, independent of sex. However, it may be pertinent to note that for the same 20-minute reallocation of time from MVPA to any other movement behaviour, the non-significant predicted changes were consistently higher in girls, possibly due to girls accruing less MVPA prior to reallocation. Furthermore, the ternary heat maps (Supplementary Figure 1) suggest higher MVPA to be linked with a lower aPWV in girls, potentially suggesting intensity of physical activity may be key to achieve change in arterial health for this population. Conversely, in boys, intensity may be of less importance for arterial health, as demonstrated by the lack of effect of reallocating MVPA to LPA on AIx (Supplementary Figure 1). This therefore suggests that both LPA and MVPA are important for aPWV in boys. However, as boys accrued a larger volume of MVPA compared to girls, this must be interpreted with caution. Nonetheless, these predictive changes support the importance of MVPA in children (UK Chief Medical Officer C, 2019) whilst also indicating

Table 4. Effect of reallocating 20-min of time from behaviour in columns to behaviours in rows for boys and girls, presented as percentage change.

	Girls				Boys			
PP	SED	LPA	MVPA	Sleep	SED	LPA	MVPA	Sleep
SED	–	−0.30	0.10	−0.25	–	−0.33	0.05	−0.26
LPA	0.29	–	0.39	0.03	0.32	–	0.36	0.05
MVPA	0.04	−0.27	–	−0.22	0.06	−0.28	–	−0.21
Sleep	0.25	−0.05	0.35	–	0.34	−0.07	0.31	–
Aix								
	SED	LPA	MVPA	Sleep	SED	LPA	MVPA	Sleep
SED	–	0.74	0.91	−0.49	–	0.96	0.86	−0.56
LPA	−0.66	–	0.24	−1.16	−0.85	–	0.00	−1.42
MVPA	−0.37	0.37	–	−0.86	−0.39	0.58	–	−0.95
Sleep	0.48	1.22	1.38	–	0.58	1.51	1.40	–
PWV								
	SED	LPA	MVPA	Sleep	SED	LPA	MVPA	Sleep
SED	–	0.07	0.95	−0.28	–	0.09	0.77	−0.28
LPA	−0.05	–	0.89	−0.34	−0.07	–	0.70	−0.35
MVPA	−0.37	−0.31	–	−0.66	−0.33	−0.25	–	−0.62
Sleep	0.27	0.34	1.22	–	0.32	0.36	1.05	–

that LPA may have a greater positive effect on arterial health than previously perceived (Füzéki, Engeroff, & Banzer, 2017).

The primary strength of this study was the use of a compositional approach to understand the overall influence of movement behaviours on arterial measures. Additionally, the use of SWC% as a representation of the MCID, as opposed to the traditional method of 1 SD, provided a more meaningful context to predictive changes in arterial measures (Wells et al., 2001). However, this study is not without limitations. First, it is important to acknowledge that the cross-sectional nature and small sample size of the present study may limit the generalisability of the findings and future investigation is required to explore the associations found in a larger population. Secondly, accounting for the physiological dependence of AIx on HR was not possible therefore possibly misrepresenting the vascular state in the present sample. The use of accelerometers without inclinometers may not fully distinguish between sedentary time and LPA, due to a lack of sensitivity and inability to identify postural changes (Carson et al., 2016; Howard et al., 2015). Moreover, given that this study only monitored participants for seven-consecutive days, with as little as three days included for some participants, some movement behaviours may have been under- or over-estimated, as behavioural variation may not have been accounted for, in addition to creating a lack of distinction between LPA and sedentary time. It is also pertinent to note that a significant difference in maturity was present between girls and boys, therefore, whether observed differences in health outcomes were solely attributable to sex, independent of maturity, remains to be elucidated and warrants further investigation. Finally, whilst the predictive changes in arterial measures suggest both positive and negative effects of reallocating 20 min of time between behaviours in future interventions, these models are based on the present data, thereby limiting generalisability. Additionally, predictive modelling provides no indication regarding the duration of intervention necessary to elicit such changes, nor the duration over which they should be sustained to impact health.

5. Conclusion

In conclusion, MVPA was the most potent stimulus for change in arterial health. However, even with a 20-minute reallocation from any other movement (i.e. sleep, sedentary time and LPA) to MVPA, no significant predicted changes were evident in arterial measures, thereby highlighting the high potential dose of MVPA required to improve arterial health. However, of importance, daily movement behaviours cannot predict arterial stiffening in isolation, demonstrating the need to adopt a compositional approach in future research. Future research should not only seek to further explore the relationship between movement compositions and arterial health, but to identify and control for additional mediatory or modulatory factors.

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