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Research article

Body morphology and gait transition of adolescents: A comprehensive approach

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Abstract

The purpose of the current study was two-fold: i) to find the best predictive model, consisting of anthropometric, body composition and body proportion variables, in explaining gait transition among adolescents; ii) to identify possible sex differences in these relationships. The sample included 116 participants (63 boys and 53 girls, aged 14.3 ± 0.5 years, height: 1.69 ± 0.07 m, weight: 58.7 ± 10.7 kg). The effects of sex and differences between walk-to-run (WRT) and run-to-walk transition (RWT) speeds were assessed using the 2-way ANOVA, and Pearson's coefficient correlation was used to examine relations between preferred transition speed (PTS) and body characteristics. Backward multiple regression was applied to identify the best-fit model for the PTS. Boys displayed significantly higher PTS compared to girls ($t = 4.407$, $p < 0.001$), as well as WRT and RWT speeds ($F = 19.423$, $p < 0.001$). In the boy's sample, various longitudinal, transversal, and body composition measures showed moderate association (r = 0.312–0.412) with PTS, whereas the best-fitting model included body fat percentage, ankle diameter and shoulder diameter ($R^2 = 0.383$, $p < 0.01$). In girls, only body height, leg length, and ankle diameter were significantly related to PTS ($r \sim 0.27$, $p < 0.05$), while the best-fit model extracted body height as the only significant factor in the manifestation of the gait transition ($R^2 = 0.081$, $p < 0.05$). The present results indicate that the relationship between body morphology and PTS has a sex-specific influence and that different factors, distinct to those of adults, affect the values of the transition speed of early adolescents.

KEYWORDS: preferred transition speed, anthropometry, body composition, body proportions

Introduction

Locomotion velocity at approximately 7.2 km/h produces a gait shift from walking to running (and vice-versa) and is often defined as the preferred transition speed (PTS) (Thorstensson & Roberthson, 1987). Metabolic energy cost has long been considered a major determinant in gait transformation (Hreljac, 1993). However, this theory has been questioned since a number of studies have demonstrated that speeds at preferred vs energetically optimal transition are significantly different (Minetti et al., 1994; Rotstein et al., 2005; Sentija et al., 2012). Anthropometric (Raynor et al., 2002; Hreljac, 1995; Ranisavljev et al. 2014a), biomechanical (Minetti et al., 1994; Ranisavljev et al., 2014b; Dobrijevic et al., 2020), and perceptual (Daniels and Newel, 2003) factors have been identified as potential predictors of PTS, for which mechanical efficiency and load act as a triggering mechanism, while anthropometric features represent a physical limitation (Kung et al., 2019).

Although the pivotal role of anthropometry in quadruped gait transition has been well-documented (Kung et al., 2019), conflicting findings remain regarding this relationship during human bipedal locomotion. In general, the majority of previous research evaluated longitudinal anthropometric measures; leg length (Thorstensson & Roberthson, 1987; Hreljac, 1995; Tseh et al., 2002), foot length (Raynor et al., 2002), or lateral malleolus height (Hreljac, 1995) have shown a weak-to-moderate association with PTS. However, of note is that the aforementioned studies neglected the possible influence of transversal or body composition variables on gait transition, which should be considered an important limitation, given that body shape and composition features strongly affect walking/running economy and performance (Bramble & Lieberman, 2004). Only two studies (Sentija et al., 2012; Ranisavljev et al., 2014a) obtained circular and transversal evaluation, while one (Ranisavljev et al, 2014a) additionally evaluated body proportion and composition status. Specifically, Ranisavljev et al. (2014a) found that, except longitudinal measures (leg and shank length, malleolus height), variables such as bitrohanteric diameter, as well the fat percentage and lower-body muscle mass, represent a significant physical limitation for the PTS. Furthermore, they observed that the best-fit model, which consisted of four proportion measures (thigh/lower length, leg muscle mass/body weight, leg/foot length, shoulder/bitrohanteric diameter), explained about 50% of PTS variability, while a model without body proportions explained only 20% of gait transition. In contrast, Sentija et al. (2012) observed that the relationship between anthropometry and gait transition has a sex-specific influence: in males, PTS was positively related to longitudinal (body height, thigh and foot length) measures, while in females foot length, calf and thigh girth correlated with PTS, and these associations were inversed. Considering the above, it can be assumed that gait transition may be affected by a pool of physical components, rather than by a single factor, and that comprehensive evaluation of body status, separately in both sexes, could shed a light on this topic.

Other than the influence of sex, the association between body components and gait transition could be affected by other factors, primarily related to age characteristics. Indeed, novel research by Ducharme and coworkers (2020) revealed that age and sex, together with height and body-mass index, predict gait cadence with accuracy up to 97%. This is not surprising, given that kinematic and spatio-temporal gait parameters constantly change from prepubescence to adulthood (Froehle et al., 2013). For instance, although self-selected walking velocity stays constant with age, there is an apparent offset in ankle and foot kinematics between children and adults (Ganley & Powers, 2005). Moreover, stride length and frequency, together with step width, tend to continuously change through the years, reaching full maturity only at the adult level (Thevenon et al., 2015; Froehle et al., 2013). The specific period of interest could be early adolescence (around 14 years), since this age is characterized by the maturation of gait patterns; mature walking emerges between 13 and 14 years and running between 15 and 17 years (Kung et al., 2019). Furthermore, during this period, anthropometric changes are emphasized (Medeiros et al., 2014), reaching offset between boys and girls (Mirwald et al., 2002). Therefore, it seems relevant, in this age group, to investigate how the gait transition is affected by body status, and to identify possible sex influence on this relationship. Unfortunately, compared to adults, there is scarce data regarding PTS complexity in youth. To the best of our knowledge, only Tseh and coworkers (2002) investigated the association between anthropometric status and gait transition in a cohort of 30 healthy boys and girls (11–15 years). They found a strong correlation (r=0.71) between leg length and PTS, though this study included a limited number of anthropometric features (i.e., height, body mass, leg length), and did not investigate possible sex influence.

Generally, the role of body components status in gait reorganization has never been comprehensively assessed in adolescent boys and girls. Therefore, the aim of the current study was two-fold: i) to find the best predictive model, consisting of anthropometric, body composition, and body proportion variables, in explaining gait transition among the adolescent population; ii) to identify possible sex differences in these relationships.

Methods

Subjects

The sample consisted of 63 male (age 14.16 ± 0.64 years) and 53 female (14.44 ± 0.33 years) participants. This sample size was justified by a priori power analyses, using G-power software with a target correlation value (r) of 0.3, an alpha level of 0.05, and power (1-ß) of 0.80 (Eng, 2003). All participants were healthy, without a history of musculoskeletal injuries or cardiovascular health issues. Also, participants and their parents were fully informed about experimental procedures and potential risks and signed a written informed consent prior to participation in the study. The study was approved by the Institutional Ethics Committee and conducted in accordance with the Declaration of Helsinki.

Experimental protocol and testing

The experimental protocol consisted of two laboratory testing sessions; in the first session, anthropometric and body composition status were evaluated, while transition speed data were collected during the second session. Each session was performed in the morning hours (8–11 AM), with constant room temperature (20–25°).

The anthropometric measurements included longitudinal, circular, and transversal dimensions according to the recommendations of the Westat (1988). Longitudinal anthropometric variables were measured with a portable Martin's anthropometer (Siber-Hegner, Switzerland), with 0.1 cm accuracy, and they included: body height, sitting height (distance between the sitting surface and the top of the head), leg length (distance between trochanter major and the floor), thigh length (distance between trochanter major and patella), lower leg length (distance between caput fibulae and lateral malleolus), foot length (distance between the back of the heel and the top of the longest toe), lateral malleolus height (distance between the edge of the lateral malleolus and the floor). Circular variables were taken with a non-extensible 2-m measuring tape Harpenden (Holtain Ltd), with 0.1 cm accuracy, and they included upper and lower leg girth. Transversal variables were taken using a cephalometer (GPM Instruments, Switzerland), with 0.1 cm accuracy and included: bitrohanteric diameter (distance between lateral points of right and left trochanter major), bicristal diameter (distance between right and left iliac crest), ankle diameter (distance between medial and lateral malleolus), foot diameter (distance between the edges of the first and the fifth metatarsal bone), knee diameter (distance between medial and lateral femoral epicondyles), and shoulder diameter (distance between right and left acromion).

Body composition variables were measured with an In-Body 720 device (Biospace Co., Seoul, Korea) using Direct Segmental Multi frequency-Bioelectrical Impedance Analysis (DSM-BIA method) and included: body mass, body fat percentage, body fat mass, free fat mass, and muscle mass. Prior to testing, the subjects were instructed not to eat anything in the morning, avoid any kind of exercise 24 before analysis and evacuating the bowels and bladder before the measurement. Subjects were in the standing position for at least five minutes prior to measurement for the redistribution of body fluids. During the measurement, all subjects were in light sport clothing and had no metal accessories.

The Walk-to-Run (WRT) and Run-to-Walk transition speed (RWT) were measured using the incremental protocol on a motorized treadmill. Specifically, the initial walking speed was set at 5 km/h and was progressively increased every 10 s by 0.2 km/h, until the running transition. After the 15-minute rest, the test protocol was reversed, i.e., where running speed begins at 9 km/h and decreases by 0.2 km/h. The order of the testing procedures within each subject was randomly assigned (Tseh et al., 2002; Rotstein et al., 2005). PTS was estimated as the average value between WRT and RWT speed. Due to the fact that children aged 10–14 years, compared to adults, have a less developed ability to assess which of the two gait modes requires less effort at speeds around PTS (Kung et al., 2020), the experienced researchers were careful and very precise in explaining the test protocol, and each of the subjects performed the test twice. The average value from the two measurements was taken for the analysis.

Statistical analysis

The Shapiro-Wilks's test was used to test the normality of the distribution. A series of independent t-tests were used to determine the sex differences in the body characteristics (anthropometric and body composition measures) and PTS. To analyze the effects of sex and differences between WRT and RWT speeds, the 2-way ANOVA (model: mixed between-within subjects) was used. Pearson's coefficient correlation was used to examine relations between PTS and body characteristics. Qualitative interpretations of the r coefficients were defined by Hopkins et al. (2009) (0.00–0.09 trivial; 0.10–0.29 small; 0.30–0.49 moderate; 0.50–0.69 large; 0.70–0.89 very large; 0.90–0.99 nearly perfect; 1.00 perfect). For discussion purposes, the correlation coefficients were directly compared with their 95% confidence intervals. Additionally, a backward multiple regression was applied to identify the best fit model for the PST. Before regression analysis, multicollinearity was explored using a variance inflation factor (VIF), and each variable that had VIF 5 or higher, was excluded from the model (Ranisavljev et al., 2014a). Statistical analysis was processed using the IBM SPSS Statistics software package (Version 21, SPSS Inc, Chicago, IL, USA). All data are presented by mean and standard deviation. $p \leq 0.05$ were taken as a statistically significant determinant.

Results

Significant sex-differences were noted in the majority of anthropometric and body composition variables. Generally, boys were heavier and taller, with longer extremities, greater muscularity, and lower body fat (all $p < 0.01$), while females demonstrated higher body-proportion values ($p < 0.01$) (Table 1).

Table 1: Sex-differences in anthropometric and body composition variables

Variables	Boys	Girls
Body height (cm)	171.13 ± 7.85**	167.45 ± 6.24
Leg length (cm)	88.11 ± 4.49**	84.51 ± 4.18
Sitting height (cm)	88.76 ± 4.55	88.47 ± 2.83
Upper leg length (cm)	41.45 ± 2.47**	40.20 ± 2.33
Lower leg length (cm)	38.17 ± 2.65**	36.60 ± 2.15
Foot length (cm)	25.83 ± 1.20**	24.27 ± 1.26
Malleolus height (cm)	7.10 ± 0.70**	6.32 ± 0.71
Upper leg girth (cm)	54.15 ± 6.18	54.06 ± 4.63
Lower leg girth (cm)	36.16 ± 3.14**	34.62 ± 2.64
Bi-trohanteric diameter (cm)	29.89 ± 2.03	30.47 ± 1.55
Bi-cristal diameter (cm)	26.24 ± 1.57	26.01 ± 1.58
Ankle diameter (cm)	7.33 ± 0.48**	6.72 ± 0.37
Foot diameter (cm)	9.25 ± 0.48**	8.61 ± 0.42
Knee diameter (cm)	9.67 ± 0.42**	8.79 ± 0.44
Shoulder diameter (cm)	37.77 ± 2.40**	36.07 ± 1.69
Index upper leg / lower leg	1.49 ± 0.08	1.56 ± 0.07**
Index shoulder / hip diameter	1.26 ± 0.08**	1.18 ± 0.05
Index leg length / foot length	3.41 ± 0.14	3.48 ± 0.12**
Index sitting height / leg length	1.00 ± 0.04	1.05 ± 0.04**
Body mass index (kg/m^2)	20.84 ± 3.12	19.79 ± 2.62
Body mass (kg)	61.39 ± 11.99**	55.52 ± 7.98
Body fat %	15.80 ± 7.89	22.81 ± 5.70**
Body fat (kg)	10.27 ± 6.88	12.96 ± 4.92*
Free fat mass (kg)	51.12 ± 7.79**	42.58 ± 4.76
Muscle mass (kg)	28.31 ± 4.65**	23.17 ± 2.82

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

Boys displayed significantly higher PTS compared to girls (*t* = 4.407, $p < 0.001$). Accordingly, the transition speeds of WRT and RWT were significantly higher for boys compared to girls (*F* = 19.423, $p < 0.001$). Subjects of both sexes demonstrated significantly higher transition speed during RWT compared to WRT (*F* = 240.0, $p < 0.001$), while the interaction sex × transition mode (i.e., WRT - RWT) was not statistically significant (*F* = 2.560, $p = 0.112$) (Figure 1).

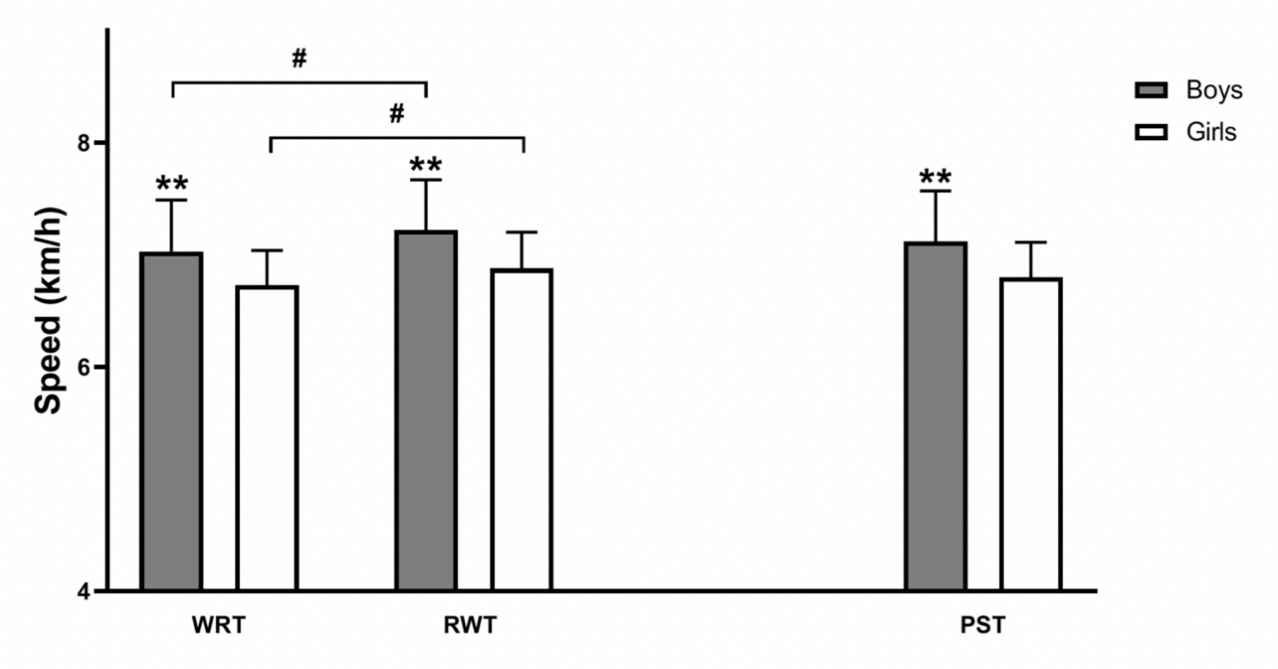

*Figure 1: Transition speed (WRT, RWT, PTS) values for boys and girls (** indicates a significant sex difference (p < 0.01); # indicates a significant speed transition difference (p < 0.01))*

Generally, boys displayed weak-to-moderate correlations between PTS and various longitudinal, transversal, and body composition measures. The sitting height and body height were longitudinal variables with the highest correlation with PTS (*r* = 0.359 - 0.398, $p < 0.01$), while ankle diameter showed the highest correlation with PTS from all transversal variables. All body composition data, except total body mass, showed significant relations with PTS (*r* = 0.262 - 0.335, $p < 0.05$) (Table 2).

Regression analysis entered eight of the predictor variables (body height, SMM and body fat mass were excluded due to high VIF > 5). The best-fitting model included the variables body fat percentage, ankle diameter, and shoulder diameter (F = 12.196, p < 0.01), which explained 38% of the PTS variance. The equation for the model was 3.172 + 0.257 × ankle diameter + 0.064 x shoulder diameter - 0.021 × body fat % (Figure 2).

Table 2: Correlation coefficients between body components (anthropometric and body composition) and gait transition, separately by sex and for the whole sample

	Correlation with PTS		
Variables	**Boys**	**Girls**	**Whole sample**
Body height (cm)	0.359**	0.283*	0.395**
Leg length (cm)	0.210	0.273*	0.340**
Sitting height (cm)	0.398**	0.131	0.318**
Upper leg length (cm)	0.139	0.111	0.210*
Lower leg length (cm)	0.312*	0.170	0.351**
Foot length (cm)	0.326**	0.194	0.416**
Malleolus height (cm)	0.059	0.087	0.240**
Upper leg girth (cm)	-0.082	-0.145	-0.090
Lower leg girth (cm)	-0.045	-0.096	0.043
Bitrohanteric diameter (cm)	0.180	0.103	0.082
Bicristal diameter (cm)	0.081	-0.135	0.031
Ankle diameter (cm)	0.412**	0.275*	0.499**
Foot diameter (cm)	0.286*	-0.006	0.359**
Knee diameter (cm)	-0.087	0.152	0.274**
Shoulder diameter (cm)	0.381**	0.068	0.393**
Index upper leg / lower leg	-0.077	-0.100	-0.223*
Index shoulder / hip diameter	0.201	-0.060	0.300**
Index leg length / foot length	-0.090	0.082	-0.130
Index sitting height / leg length	0.201	-0.216	-0.112
Body mass (kg)	0.043	0.003	0.133
Body fat %	-0.371**	-0.109	-0.415**
Body fat (kg)	-0.290*	-0.105	-0.296*
Free fat mass (kg)	0.321**	0.113	0.416**
Muscle mass (kg)	0.335**	-0.148	0.421**

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

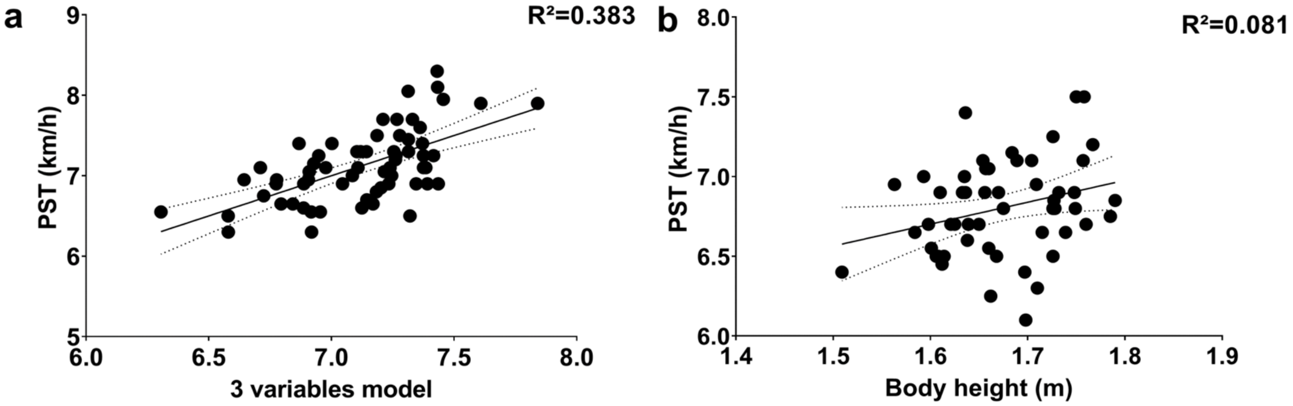

Figure 2: Prediction of PTS based on a model with 3 variables (body fat percent, shoulder and ankle diameter) in boys (panel a) and a model with a body height in girls (panel b)

In contrast, in girls, only two longitudinal (body height, leg length) and one transversal (ankle diameter) variables were significantly related with PTS ($r \sim 0.27$, $p < 0.05$) (Table 2).

Further regression analysis revealed that, of the three predictor variables, the best-fit model extracted body height as the only significant factor in explaining 8% of the variance of the PTS ($F = 4.483$, $p < 0.05$). The equation for the model was $4.501 + 1.375 \times$ body height (Figure 2).

Discussion

To the best of our knowledge, this is the first study to comprehensively investigate the association between body measures and gait transition in youth. The main results indicate that transition speed significantly differs between boys and girls, and that body components differently affect PTS between the sexes. Several longitudinal, transversal and body composition variables have weak-to-moderate correlation with PTS in male adolescents: body fat, ankle, and shoulder diameter explain almost 40% of PTS variance. Body height, leg length and ankle diameter are the only three variables in the girl sample with weak correlation with PTS. Based on these findings it seems that the relationship between body components and gait transition is sex-dependent, and that body physique should be considered an important factor in gait transition, but only in boys.

With respect to the whole sample of the current study, correlation analysis extracted numerous significant connections between PST and body measures, including longitudinal (body height, leg length, etc.), transversal and body composition variables. The influence of sitting height, lower leg, and foot length on PTS is in line with previous reports with adults (Hreljac, 1995; Rayner et al., 2002; Šentija et al., 2012; Ranisavljev et al., 2014a), suggesting that longitudinal features affect gait transition from adolescence to adulthood. Those longitudinal factors influence the stride length and frequency and may be considered as a limiting factor of the PTS (Kung et al., 2018), predominantly for the walk-to-run transition during speed increase. This is partially expected considering that the period of the largest increase in leg length usually begins to slow down around the age of the present sample (Mirwald et al., 2002).

However, when these associations were separated by sex, boys showed a higher number and level of correlations compared to girls. Specifically, 12 longitudinal, transversal and body composition variables showed weak-to-moderate relationships to PST in boys, while only three weak associations (body height, leg length, and ankle diameter) were observed in girls. Boys' shoulder and ankle diameters, with body fatness, were able to explain approximately 40% of changes in gait transition, while in girls, only body height was a significant predictor of PST, explaining only 8% of variance. Moreover, sex differences were observed in PTS: boys were shown to be faster than girls, in both walk-to-run and run-to-walk variants. This finding further supports the idea that males choose walking at faster speeds over slow-speed running (Šentija & Marković, 2009; Šentija et al., 2012). In contrast, the relatively wider hips and smaller feet of girls (see Table 1) reduce stride length and increase stride frequency (Froehle et al., 2013), which have a positive influence on slow walking; however, during fast walking these structural features may have a disadvantageous effect (Hak et al., 2013). Interestingly, our findings do not appear to support results of the Šentija et al. (2012) in adults, where PST was not significantly different between men and women. Nevertheless, it should be noted that those authors tested smaller a sample than in the present study (n=48), and although the significance was not met, males were faster than females for about 0.20 km/h, which is relatively close to our results (i.e. difference was 0.30 km/h).

Considering the presented differences between boys and girls, it is evident that the relationship between gait transition and body components has a sex-specific influence. This is highly important, since only a small percent of youth females participated in the previous PTS research (Kung et al., 2020), while studies on adults consisted of combined samples (Minetti et al., 1994; Hreljac, 1995; Tseh et al., 2002; Raynor et al., 2002), which could have led to misleading results (see Table 2). In fact, only Šentija et al. (2012) investigated the relationship between PST and anthropometric features, comparing young men and women. Similar to our results, they found that body height and leg length were moderately related to gait transition for the whole sample, however, the transversal and circular measures have different correlation values (and signs) between men and women. Based on this, it seems that these sex differences are not exclusively related to the adolescence period and could be expected across wide range of age groups.

Still, the present findings demonstrated a certain number of (di)similarities compared to previous studies in adults. Ranisavljev et al. (2014a) reported that bitrochanteric diameter is significantly related to PTS in adult males, and Šentija et al. (2012) observed high negative relation between females PTS and circular body dimensions (thigh and calf girth). Conversely, we found that ankle, foot, and shoulder diameter were related with PTS in boys, and a small relationship between ankle diameter and PTS was observed in girls. The pronounced diameter-PTS association found within the current study could be explained due to the age-specific growth patterns of anthropometric dimensions. During early adolescence, longitudinal growth has almost reached the adult level (Mirwald et al., 2002), while increase in transversal dimensions is expected until the age of 14 to 15 in girls, and until the age of 16 in boys (Zivicnjak et al., 2008). Growth in length, without increasing in width, reduces body stability (Rauch, 2005), thus dis-appropriate maturation between longitudinal and transversal features may affect gait mechanics during walking, especially at faster speeds, where dynamic stability is impaired (Dedieu & Zanone, 2012). This particularly relates to the ankle joint, since ankle mechanics are a major factor in gait transition (Ranisavljev et al., 2014b), and neuromuscular immaturity of the ankle has been recognised as a key determinant in children to achieve adult-like gait patterns (Ganley & Powers, 2005). Considering the above, larger diameters with longer body parts could be preferable in preserving gait stability during walking at faster speeds, resulting in higher PTS.

In regard to the body composition, the present results corroborate well with the study of Ranisavljev et al. (2014a) conducted on a sample of young male adults, in which the relationship between body fat and PTS was inversed. Accordingly, Ilic et al. (2012) demonstrated that a decrease in body fat and an increase in lean mass lead to a higher PTS in overweight adults. The gait of obese children (and adults), compared to the non-obese peers, are known to have longer stance duration, greater stride width and also, greater loads across lower-body joints (Thevenon et al., 2015). Hence, fast walking is mechanically highly demanding, which results in running transition at relatively lower speeds. In contrast, the positive association between muscle mass and PTS found in the present study does not confirm the results of the Ranisavljev et al. (2014a). Although this research group did not find significant association between gait transition and whole-body muscle mass, the ratio between leg lean mass and body weight showed to be an important predictor of PTS. This is not surprising, since force production of the ankle dorsal flexors and tibialis anterior has been recognized as an important triggering factor in gait transition (Kung et al., 2018), which could further explain the positive correlation found between ankle diameter and PTS in the present study.

Altogether, the present results indicate that anthropometric and body composition status have a moderate influence on gait transition in male adolescents, while in adolescent females the role of body measures seem to be negligible. Compared to the previous reports on adults, our findings suggest that i) the influence of body fatness, muscle mass, and leg length on gait transition, remains constant from adolescence to adulthood, ii) while the role of anthropometric features, mainly transversal and circular, vary through maturation. Based on a regression analysis, male adolescents with athletic body shapes (i.e., broad shoulders, low fats, and stabile ankle joint) may be suitable to walk at higher speeds, resulting in higher PTS values. In contrast, in girls, only body height has relatively small influence on PTS, indicating that other factors, probably related to mechanical muscle properties (Ranisavljev et al., 2014b; Dobrijevic et al. 2020), should be considered as a limitation in gait transition among female adolescents.

Strengths and limitations of the study

There are several strengths of the current study. Firstly, our research design included a considerably large sample (n=116), which would be sufficiently representative about anthropometric and body composition status, as well PTS values, among early adolescent children. In contrast, previous studies included relatively small sample sizes (≤ 54), in both adolescent and adult populations. Secondly, we investigated the association between body components and PTS, separately in both sexes. Again, the majority of previous research neglected the influence of sex, which could have led to biased results, as our data showed. Thirdly, we applied a comprehensive body evaluation where--except longitudinal--transversal, and body composition features were obtained, which in turn demonstrated a somewhat stronger relationship with PTS compared to longitudinal measures. Previously, only Ranisavljev et al. (2014a) obtained the mentioned body parameters, but their sample included only adult males. However, as a main limitation of the current study, it should be noted that differences in biological age for boys and girls were not calculated.

Conclusion

In conclusion, the present results indicate that different body variables show the relationship with PTS in early adolescent boys and girls. In the male sample, various height, length, and body composition (muscle mass and body fat) measures showed a moderate association with PTS. On the female side, longitudinal body dimension (body height and leg length) and ankle diameter demonstrated a weak correlation with PTS in girls. Body fats, and ankle and shoulder diameters explain almost 40% of PTS in boys, while in girls, only body height was significant predictor of PST, explaining only 8% of gait transition variance. Compared to adults, the present results indicate that during maturation, different factors affect values of the transition speed of early adolescents, and these factors are opposite to adults. This sheds a light on the complexity of the gait reorganization phenomenon in the specific sample of adolescents.

Declaration of competing interest

The authors have no conflict of interest to disclose.

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Povzetek

Namen študije je bil dvojen: i) najti najboljši napovedni model, sestavljen iz spremenljivk antropometrije, telesne sestave in telesnih proporciev, da bi pojasnili prehodno hitrost med hojo in tekom pri mladostnikih; ii) ugotoviti možne spolne razlike v teh odnosih. V vzorec je bilo vključenih 116 udeležencev (63 fantov in 53 deklet, starih 14,3 ± 0,5 leta, višina: 1,69 ± 0,07 m, teža: 58,7 ± 10,7 kg). Učinki spola in razlike med hitrostjo prehoda od hoje do teka (WRT) in hitrostjo prehoda od teka do hoje (RWT) so bili testirani z 2-smerno ANOVO, korelacija Pearsonovega koeficienta pa je bila uporabljena za preučitev razmerij med izbrano hitrostjo prehoda (PTS) in značilnostjo telesa. Za identifikacijo najboljšega napovednega modela za PTS je bila uporabljena povratna večkratna regresija. Fantje so pokazali bistveno višji PTS v primerjavi z dekleti ($t = 4,407$, $p < 0,001$), pa tudi hitrosti WRT in RWT ($F = 19,423$, $p < 0,001$). Pri fantih so različne vzdolžne in prečne telesne spremenljivke, kot tudi spremenljivke telesne sestave pokazale zmerno povezavo ($r = 0,312 - 0,412$) s PTS, medtem ko je najboljši napovedni model, vključeval odstotek telesne maščobe, premer gležnja in premer ramen ($R^2 = 0,383$, $p < 0,01$). Pri deklicah so bile s PTS značilno povezane le telesna višina, dolžina noge in premer gležnja ($r \sim 0,27$, $p < 0,05$), medtem ko je najboljši napovedni model pokazal telesno višino, kot edini pomemben dejavnik pri prehodni hitrosti iz hoje v tek ($R^2 = 0,081$, $p < 0,05$). Rezultati kažejo, da ima razmerje med telesno morfologijo in PTS spolno specifičen vpliv in da različni dejavniki nasprotno, kot pri odraslih, vplivajo na vrednosti prehodne hitrosti v zgodnjem mladostništvu.

KLUČNE BESEDE: izbrana hitrost prehoda, antropometrija, telesna sestava, telesni proporci

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