Gait & Posture 84 (2021) 352–356

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Relationships between types of balance performance in healthy individuals: Role of age

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ARTICLE INFO

Keywords:
Postural control
Children
Adolescents
Adults
Associations

ABSTRACT

Background: Balance is considered to be task-specific as indicated by studies reporting only small-sized and non-significant correlations between types of balance (e.g., static, dynamic). However, it remains unclear whether these associations differ by age and the comparability of studies is limited due to methodological inconsistencies.
Research question: Are associations between types of balance performance affected by age in children, adolescents, and young adults?
Methods: Static, dynamic, and proactive balance performance was assessed in 30 children (7.6 ± 0.6 years), 43 adolescents (14.7 ± 0.5 years), and 54 young adults (22.8 ± 2.8 years) using the same standardized balance tests. Pearson's correlation coefficients (r) were calculated for associations between types of balance and statistically compared to detect differences between age groups.
Results: Except for the association between static (i.e., medio-lateral [M/L] sway) and proactive (Y-balance test) balance performance in young adults ($r = .319$, $p < .05$), our analyses revealed small-sized and non-significant associations between measures of static, dynamic, and proactive balance performance in children ($-.302 \leq r \leq .245$, $p > .05$), adolescents ($-.276 \leq r \leq .202$, $p > .05$), and young adults ($-.120 \leq r \leq .161$, $p > .05$). Significant differences between age groups were observed for associations between dynamic and proactive balance, which were lesser in young adults ($r = .161$) compared to adolescents ($r = -.276$, $p = .017$) and children ($r = -.302$, $p = .023$) and for associations between static (i.e., M/L sway) and proactive balance, which were larger in young adults ($r = .319$) compared to adolescents ($r = -.131$, $p = .029$).
Conclusions: Practitioners (e.g., PE teachers) should be aware that associations between types of balance performance are small and hardly affected by age in youth. Therefore, they should be trained and tested individually in children, adolescents, and young adults.

1. Introduction

Sufficient balance performance is an indispensable prerequisite for human beings to successfully cope with activities of daily life (e.g., walking, climbing stairs). According to Shumway-Cook and Woollacott [1], balance can be subdivided into static steady-state (e.g., standing), dynamic steady-state (e.g., walking), proactive (e.g., anticipated slip on a wet floor), and reactive (e.g., tripping over an unseen stair) balance. To ascertain whether these types of balance are associated with each other or represent separate skills, representative measures of the aforementioned balance performances have been assessed and correlated with each other. For example, Muehlbauer et al. [2] investigated associations between static steady-state (i.e., two-legged stance), dynamic steady-state (i.e., 10-m walk test), proactive (i.e., functional reach test [FRT]), and reactive (i.e., perturbed stance) balance performance in healthy children. Except for two comparisons (i.e., center of pressure [CoP] sway in anterior-posterior direction during static and perturbed standing: $r = .458$, $p < .05$; CoP sway in medio-lateral direction during static standing and FRT performance: $r = -.530$, $p < .05$), these researchers [2] found only small-sized ($-.232 \leq r \leq .431$) and non-significant ($p > .05$) correlations between types of balance performance. Based on these results, it was concluded that balance is a task-specific rather than a general ability in children. Other studies reported similar results in groups of adolescents [3], young [4] and middle-aged [5] adults, as well as in seniors [6].

Balance performance is not stable over the lifespan but increases in

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https://doi.org/10.1016/j.gaitpost.2021.01.008
Received 28 May 2020; Received in revised form 10 December 2020; Accepted 12 January 2021
Available online 13 January 2021

youth, peaks in young adults, and decreases in seniors [7]. Therefore, associations between types of balance may also be affected by age. For instance, as balance performance still develops in children, different balance tasks may be executed more easily due to a comparatively low level of task automation and a better ability to switch between the execution of different tasks in this age group. In contrast, young adults probably possess a higher level of movement automation which increases the specificity of movement control. Consequently, one could expect that associations between types of balance performance might be larger in children and adolescents as compared to adults. In this regard, Kiss et al. [8] performed a systematic review and meta-analysis by aggregating results and statistically comparing correlations reported in single studies to quantify associations between types of balance in healthy individuals across the lifespan. Supporting the notion, that balance is task-specific rather than a general ability, correlations between types of balance were small ($.09 \le r \le .54$), irrespective of the age group considered (i.e., children, adolescents, young, middle-aged, and old adults). Moreover, when statistically comparing correlations between types of balance performance of different age groups, the researchers [8] revealed – contrary to our assumption that associations might be larger in younger individuals – the association between static and dynamic steady-state balance in children ($r = .09$) to be significantly ($p < .01$) smaller than that in old adults ($r = .31$). However, Kiss et al. [8] argued that this age-effect may result from methodological inconsistencies between studies. More specifically, the vast majority of studies included in their analysis used different balance tests, measures, and conditions and was limited to a single age group. For example, both Humphriss et al. [9] as well as Witkowski et al. [10] investigated associations between static and dynamic steady-state balance. However, one study [9] examined associations between heel-to-toe stance on a beam (static balance) and heel-to-toe beam walking (dynamic balance) in children aged ten years, whereas the other [10] analyzed adolescents' (14−15 years) performances in the flamingo (static balance) and the marching (dynamic balance) test. Thus, a direct comparison of associations between types of balance performance of several age groups using identical methods (i.e., testing equipment, test conditions, measures) is still lacking.

Therefore, the main purpose of the present study was to quantify associations between types of balance performance in groups of healthy children, adolescents, and young adults using identical procedures and statistically compare these associations by age group. Based on the assumption that balance is task-specific, we expected to find small-sized correlations between types of balance. We further assumed to observe age-differences for associations between types of balance performance. More precisely, we expected to find larger correlation coefficients in children and adolescents as compared to young adults. A secondary purpose of this study was to compare balance performances of different age groups with our hypothesis being that young adults would show better performances compared to younger individuals (i.e., adolescents, children).

2. Methods

2.1. Subjects

Thirty children (age: 7.6 ± 0.6 years), 43 adolescents (age: 14.7 ± 0.5 years), and 54 young adults (age: 22.8 ± 2.8 years) of both sexes participated in the study. Table 1 shows subjects' characteristics. None of the subjects had prior experience with the tests performed. Moreover, all subjects were healthy and free of any neurological, orthopedic or musculoskeletal impairments. Written informed consent and subject's assent were obtained from all subjects before the start of the study. Additionally, parent's approval was obtained for minors.

Table 1
Study subject‘s characteristics per age group.

	Children	Adolescents	Young Adults	*p*-value
n (f/m)	30 (11/19)	43 (16/27)	54 (31/23)	
Age [years]	7.6 ± 0.6	14.7 ± 0.5	22.8 ± 2.8	<.001*
Body height [cm]	131.8 ± 6.2	171.7 ± 8.8	173.5 ± 8.8	<.001+
Body mass [kg]	30.3 ± 6.3	67.0 ± 14.7	73.5 ± 14.5	<.001*
BMI [kg/m^2]	17.3 ± 2.6	22.6 ± 4.4	24.2 ± 3.3	<.001+
Maturity offset[1] [years from PHV]	−4.1 ± 0.6	1.8 ± 0.8	7.8 ± 1.9	<.001*

Notes. Values are means ± standard deviations. [1]Maturity offset was calculated by using the formula provided by Moore et al. [12]. *BMI* body mass index, *f* female, *m* male, *PHV* peak height velocity.

* indicates significant differences between all age groups ($p < .05$).

+ indicates significant differences between young adults/adolescents and children ($p < .05$).

2.2. Procedures

All tests were performed in gyms by the same skilled assessors. Testing with children and adolescents was carried out during regular physical education lessons at school, while testing with young adults took place during regular university courses. Subjects were divided into small groups and performed all measurements in a randomized order with each group starting with a different test. Before measurement, all subjects received standardized verbal instructions, a visual demonstration of the test and two practice trials to accustom themselves with the respective test. The study was carried out in accordance to the Declaration of Helsinki [11] and was approved by the local ethics committee of the University of Duisburg-Essen.

2.2.1. Anthropometric assessments

Anthropometric measurements included assessments of body height and body mass. Body height was measured to the nearest 0.1 cm using a portable standardized stadiometer (seca 217, Basel, Switzerland) and body mass was assessed to the nearest 0.1 kg with a digital scale (seca 803, Basel, Switzerland). Further, subject's body mass index (BMI) was determined by dividing body mass by the square of body height. Finally, maturity status expressed as years from peak height velocity (PHV) was calculated for all subjects using the formula provided by Moore et al. [12]. Positive values indicate that subjects have passed PHV, whereas negative values indicate that subjects are pre-PHV.

2.2.2. Static steady-state balance performance

Static steady-state balance was assessed during single leg stance on a three-dimensional force platform (AMTI AccuSway, Watertown, USA). Subjects were instructed to stand as stable as possible on their non-dominant leg (i.e., stance leg when kicking a ball) in an upright position for 30 s without shoes. Throughout the trial, subjects had to keep their arms akimbo, flex the knee of the dominant leg to about 90°, and to fixate a cross pinned to the wall approximately one meter opposite to the platform. Data was sampled at 100 Hz and filtered (4th-order Butterworth, 10 Hz cutoff frequency). Center of pressure (CoP) path length (mm), which is the distance travelled by the CoP during the 30-s trial, as well as anterior-posterior (A/P) and medio-lateral (M/L) sway were recorded and used for analysis. Two experimental trials were recorded and the better one was used for analyses.

2.2.3. Dynamic steady-state balance performance

Dynamic steady-state balance was tested using a 10-m walk test. To allow sufficient distance for acceleration and deceleration, subjects initiated and terminated their walk at least one meter before and after the 10-m walkway, respectively. All subjects were instructed to "walk as fast as possible without running" during the trial wearing their own footwear. Using a stopwatch, the time to cover the 10-m distance was recorded to the nearest 0.01 s. Subsequently, gait velocity (m/s) was calculated and used for analysis. Two experimental trials were recorded and the better one was used for analyses.

2.2.4. Proactive balance performance

Proactive balance was measured using the lower quarter Y-balance test (YBT) kit (Functional Movement Systems®, Chatham, USA) [13]. Subjects were instructed to reach as far as possible in anterior (AT), posteromedial (PM), and posterolateral (PL) direction with their dominant leg while balancing on the centralized stance platform with their non-dominant leg without shoes. Details on the procedures during this test are described elsewhere [14]. The normalized (i.e., % leg length) maximal reach distance per reach direction and the composite score (CS) were assessed and used for analyses.

2.3. Statistical analyses

All data was analyzed for normal distribution using the Shapiro-Wilk test. Subsequently, associations between types of balance within each age group were assessed by calculating Pearson's correlation coefficients (r) and classified as indicating small- ($0 \leq r \leq 0.69$), medium- ($0.70 \leq r \leq 0.89$), or large-sized ($r \geq 0.90$) correlations as proposed by Vincent et al. [15]. Additionally, differences between correlation coefficients by age group (children vs. adolescents vs. young adults) were analyzed using the following formula [16]: $z = (z1\text{-}z2)/\sqrt{(1/(n1\text{-}3) + 1/(n2\text{-}3))}$. To detect differences in balance performances between age groups, a 3 (group: young adults, adolescents, children) × 6 (balance parameter: CoP path length, gait velocity, YBT CS, YBT AT, YBT PM, YBT PL) analysis of variance (ANOVA) was performed. If significant group × balance parameter interaction occurred, Bonferroni-adjusted post-hoc tests were carried out. Further, Cohen's d was calculated in order to estimate effect sizes. According to Cohen [17], $d = 0.2$ represent small, $d = 0.5$ represent moderate, and $d = 0.8$ represent large effects. All statistical analyses were carried out using Statistical Package for Social Sciences version 24.0 with the level of significance set at $p < .05$.

3. Results

3.1. Associations between types of balance performance and the role of age

Table 2 shows respective r-values for associations between types of balance performance according to age group. Proactive balance performance is represented by the CS as it is considered the most reliable parameter of the YBT in children [18], adolescents [19], and young adults [20]. Overall, our analyses yielded small-sized and non-significant (all $p > .05$) correlations between measures of static steady-state, dynamic steady-state, and proactive balance in children ($-.302 \leq r \leq .245$), in adolescents ($-.276 \leq r \leq .202$), and in young adults ($-.120 \leq r \leq .161$), except for the association between one measure of static steady-state (i.e., M/L sway) and proactive balance which was significant in young adults ($r = .319$, $p < .05$). Moreover, statistically significant differences between age groups were found for the association between one parameter of static steady-state (i.e., M/L sway) and proactive balance as well as for the relationship between dynamic steady-state and proactive balance. With respect to the association between M/L sway and proactive balance, the correlation in young adults ($r = .319$) was significantly larger compared to that of adolescents ($r = -.131$, $z = -2.19$, $p = .029$). Regarding the association between dynamic and proactive balance, the r-value in young adults ($r = .161$) was significantly lesser compared to that of adolescents ($r = -.276$, $z = 2.11$, $p = .017$) and children ($r = -.302$, $z = 1.99$, $p = .023$).

Table 2
Pearson's correlation coefficients (r) for associations between types of balance per age group.

	Children (n = 30)			
	Static balance			Proactive balance (i.e., YBT CS)
	Path length	A/P sway	M/L sway	
Dynamic balance (i.e., gait velocity)	−.246	−.141	.233	−.302
Proactive balance (i.e., YBT CS)	.032	.020	.245	–
	Adolescents (n = 43)			
	Static balance			Proactive balance (i.e., YBT CS)
	Path length	A/P sway	M/L sway	
Dynamic balance (i.e., gait velocity)	.096	−.070	.202	−.276
Proactive balance (i.e., YBT CS)	.089	.202	−.131	–
	Young Adults (n = 54)			
	Static balance			Proactive balance (i.e., YBT CS)
	Path length	A/P sway	M/L sway	
Dynamic balance (i.e., gait velocity)	−.082	.052	−.043	.161[b,c]
Proactive balance (i.e., YBT CS)	−.119	−.120	.319[a,b]	–

Note. A/P anterior-posterior, *CoP* center of pressure, *CS* composite score, *M/L* medio-lateral, *YBT* Y-Balance test.
[a] Indicates significant correlation coefficient ($p < .05$).
[b] Indicates significant difference to adolescents ($p < .05$).
[c] Indicates significant difference to children ($p < .05$).

3.2. Differences in balance performance between age groups

Means and standard deviations for balance performances in the different tests according to age group are presented in Table 3.

3.2.1. Static steady-state balance performance

Our analysis revealed a significant group effect for CoP path length during single leg stance ($F = 80.1$, $p < .001$). Post-hoc tests showed that young adults ($p < .001$, $d = 2.54$) as well as adolescents ($p < .001$, $d = 2.11$) performed significantly better (i.e., swayed less) than children. However, there was no difference between young adults and adolescents ($p = .090$). Similar results were obtained for A/P ($F = 29.2$, $p < .001$) and M/L ($F = 49.1$, $p < .001$) sway, with post-hoc test indicating significantly better performances of young adults (A/P: $p < .001$, $d = 1.58$; M/L: $p < .001$, $d = 2.05$) and adolescents (A/P: $p < .001$, $d = 1.40$; M/L: $p < .001$, $d = 1.69$) compared to children and no differences between performances of young adults and adolescents (A/P: $p = 1.00$; M/L: $p = 1.00$).

3.2.2. Dynamic steady-state balance performance

We detected a significant effect of age group on gait velocity ($F = 19.6$, $p < .001$). Post-hoc analyses indicated faster walking speed of young adults as compared to adolescents ($p < .001$, $d = 1.37$) and children ($p = .003$, $d = 0.72$). No difference regarding gait velocity was observed between adolescents and children ($p = .122$).

3.2.3. Proactive balance performance

Concerning performance of the YBT, the analysis indicated significant effects of age group for the CS ($F = 12.1$, $p < .001$), the normalized maximal reach in PM direction ($F = 22.8$, $p < .001$), and the normalized maximal reach in PL direction ($F = 11.2$, $p < .001$). With reference to the CS and PL reach, young adults obtained significantly larger values than adolescents (CS: $p = .026$, $d = 0.64$; PL: $p = .012$, $d = 0.74$) and children

Table 3
Balance performances by age group and results of post-hoc comparisons between age groups.

	Children (CH)	Adolescents (AD)	Young Adults (YA)	Comparisons between age groups *p*-value (Cohen's *d*)
Static balance				
CoP path length [mm]	218.9 ± 57.8	127.4 ± 29.5	109.9 ± 31.8	CH – AD: <.001 (2.11) CH – YA: <.001 (2.54) AD – YA: .090 (0.57)
A/P sway [mm]	0.81 ± 0.22	0.54 ± 0.16	0.52 ± 0.15	CH – AD: <.001 (1.40) CH – YA: <.001 (1.58) AD – YA: 1.00 (0.13)
M/L sway [mm]	−0.57 ± 0.14	−0.38 ± 0.09	−0.37 ± 0.07	CH – AD: <.001 (1.69) CH – YA: <.001 (2.05) AD – YA: 1.00 (0.15)
Dynamic balance				
Gait velocity [m/s]	1.5 ± 0.4	1.4 ± 0.3	1.8 ± 0.3	CH – AD: .122 (0.49) CH – YA: .003 (0.72) AD – YA: <.001 (1.37)
Proactive balance				
YBT CS [% LL]	92.0 ± 11.5	96.7 ± 7.3	101.2 ± 6.9	CH – AD: .060 (0.51) CH – YA: <.001 (1.05) AD – YA: .026 (0.64)
YBT AT [% LL]	71.2 ± 8.8	72.2 ± 6.0	71.8 ± 7.3	CH – AD: 1.00 (0.14) CH – YA: 1.00 (0.08) AD – YA: 1.00 (0.05)
YBT PM [% LL]	102.4 ± 14.1	110.6 ± 8.8	117.6 ± 8.0	CH – AD: .002 (0.73) CH – YA: <.001 (1.44) AD – YA: .002 (0.84)
YBT PL [% LL]	102.2 ± 16.8	107.2 ± 9.6	114.2 ± 9.2	CH – AD: .198 (0.39) CH – YA: <.001 (0.97) AD – YA: .012 (0.74)

Note. Values are presented as means ± standard deviations. *AT* anterior reach direction, *A/P* anterior-posterior, *CoP* center of pressure, *CS* composite score, *LL* leg length, *M/L* medio-lateral, *PL* posterolateral reach direction, *PM* posteromedial reach direction, *YBT* Y-Balance test.

(CS: $p < .001$, $d = 1.05$; PL: $p < .001$, $d = 0.97$) whereas no differences were observed between adolescents and children (CS: $p = .060$; PL: $p = .198$). In PM direction, young adults reached farther than adolescents ($p = .002$, $d = 0.84$) and children ($p < .001$, $d = 1.44$). Additionally, adolescents reached farther in PM direction than children ($p = .002$, $d = 0.73$). Lastly, age group did not affect YBT-performance in AT direction ($F = 0.2$, $p = .844$).

4. Discussion

In accordance with our first hypothesis, we observed small-sized and non-significant (all $p > .05$) correlations between measures of static steady-state, dynamic steady-state, and proactive balance in children (-.302 ≤ r ≤ .245), in adolescents (-.276 ≤ r ≤ .202), and in young adults (-.120 ≤ r ≤ .161), except for the association of one parameter of static steady-state balance (i.e., M/L sway) and proactive balance which was significant in young adults ($r = .319$, $p < .05$). This is in accordance with the concept of task-specificity of balance and implies that a person's performance in one specific type of balance (e.g., static steady-state) is not predictive of this person's ability to perform in another type of balance (e.g., proactive). Similar results have been reported by studies in children [2,21], adolescents [3], and young adults [22]. Consequently, if balance performance is tested, examiners should either use test batteries including tests of different types of balance performance or undertake individual measurements for different types of balance. Similarly, common balance training should include manifold exercises challenging all types of balance in order to be most effective. One possible explanation for the predominantly small-sized correlations between types of balance performance relates to the different challenges these tasks pose to the postural control system. For example, during static standing only the center of mass shifts while the base of support is stable, whereas during walking the center of mass and the base of support shift. In this regard, Lajoie et al. [23] have shown that reaction times to an unpredictable auditory stimulus increased during walking as compared to standing in young adults. It was concluded, that walking required higher attentional demands than standing. Further, our results may have been influenced by task difficulty. For instance, the YBT might not be particularly difficult for young adults but represent a major challenge for children as it requires anticipatory postural adjustments. According to Hay and Redon [24], this feedforward organization of postural control develops in youth and undergoes distinct changes in children aged six to eight years, who show a transient overcontrol of posture following self-initiated postural disturbances.

We further hypothesized to find significant differences between associations of types of balance performance of different age groups. However, statistically significant differences were only found for two out of twenty-one comparisons. First, the association between one parameter of static steady-state balance (i.e., M/L sway) and proactive balance in adolescents (r = -.131) was significantly smaller compared to young adults (r = .319). This is in contrast to our assumption to find larger associations between types of balance performance in children and/or adolescents compared to young adults. However, proactive balance was measured using the CS of the YBT and two (i.e., PM and PL reach) of the three measures included in this parameter require the ability to stabilize the body in M/L direction. Although, this also applies to adolescents, the YBT is a functional test which is also associated with muscular strength, especially of the hip [25]. As muscular strength is still developing in adolescents it may be hypothesized that while they can effectively stabilize their body in M/L direction during a rather simple single-legged stance, their ability to additionally produce enough muscle force during more demanding tasks, such as the YBT, might still be insufficient. Second, dynamic steady-state and proactive balance were significantly more associated in children (r = -.302) and adolescents (r = -.276) as compared to young adults (r = .161). This is in accordance with our hypothesis to find larger associations between types of balance performance in children and adolescents as compared to young adults. With respect to different balance tasks, children and adolescents can be considered as "early in practice" whereas young adults have far more experience with such tasks due to their older age. According to a model proposed by Hikosaka and colleagues [26], the control of a motor task becomes more specific with an increasing level of movement experience. Thus, while children and adolescents may to some degree be able to switch between the execution of different tasks (e.g., static and dynamic steady-state balance), this ability is probably reduced in young adults. However, this finding is in contrast to the results reported in a systematic review with meta-analysis by Kiss et al. [8] who found the association between static and dynamic steady-state balance to be significantly smaller in children compared to old adults (≥ 60 years). Yet, it was argued that this discrepancy might be the result of the different balance tests used in the studies included in their analysis. Although, we investigated young adults only, our results support this assumption as we applied the same balance tests in children, adolescents, and young adults without finding significant differences between associations of static and dynamic steady-state balance in the age groups investigated. Further, the positive correlation in young adults (r = .161) means that a faster walking speed is associated with a farther reach in the YBT in this age group and vice versa. Contrary, the negative r-values obtained in children (r = -.302) and adolescents (r = -.276) suggest that a faster walking speed indicates poorer performance in the YBT and conversely a far reach distance obtained in the YBT is associated with slower walking speed. As the neuromuscular system of children and adolescents is still developing [27] they may have difficulties to adequately master the different challenges of dynamic and proactive balance tasks. For instance, a child may be able to effectively generate balance and strength during walking but struggle to combine balance, strength, and flexibility as needed in the YBT. However, even though we observed a significantly smaller association between dynamic steady-state and proactive balance in young adults as compared to children/adolescents, associations were overall weak and non-significant in all investigated age groups. Thus, the predictive value of a person's performance in one of these tests (e.g., 10-m walk) for the performance in the other test (e.g., YBT) is limited. Consequently, these types of balance should be trained and tested individually.

A second purpose of the present study was to compare balance performances between age groups and in support of our hypothesis, we observed mostly better performances in young adults as compared to adolescents and children. More specifically, young adults outperformed children in seven out of eight and adolescents in four out of eight comparisons of balance performance. Additionally, adolescents showed statistically better performances than children in four out of eight comparisons of balance performance. Lastly, when comparing balance performances between two age groups, the younger group never exhibited better performances than the older age group. This in accordance with other studies reporting balance performance to improve until young adulthood due to the still developing postural control system in children and adolescents [7,28,29]. For example, Cumberworth et al. [29] investigated postural sway in healthy youth aged five to 17 years using the sensory organization test and observed progressive performance increases with age. However, in the present study differences between adolescents and children were only detected regarding static steady-state and partly in proactive balance (i.e., PM reach) and this is in accordance with a systematic review and meta-analysis [30] on age differences in balance performance in youth which reported age to have a large effect on static-steady-state (standardized mean difference [SMD] = 1.20), but only small effects on proxies of dynamic steady-state (SMD = 0.26) and proactive (SMD = 0.28) balance performance. It could therefore be speculated that children possess larger adaptive reserves regarding static steady-state balance than adolescents. In fact, following five weeks of balance training Schedler et al. [31] observed significant improvements in static steady-state balance in children as indicated by decreased postural sway (-16%, $p < .05$) during single-leg stance, whereas the same training elicited slight and non-significant increases (+2%, $p > .05$) of CoP path length in adolescents.

A limitation of the present study relates to the applied tests. We opted for sophisticated biomechanical (i.e., static steady-state balance) as well as more functional physical fitness tests (i.e., 10-m walk test, YBT) providing either high internal or external validity, respectively. Nonetheless, some of these tests may have been too rudimentary to detect differences of associations between types of balance performance.

5. Conclusions

To the best of our knowledge, the present study is the first which investigated and statistically compared associations between types of balance performance between groups of healthy children, adolescents, and young adults using identical balance tests, conditions, and parameters. Our results support the notion that balance is task-specific and different types of balance should therefore be trained and tested separately in these age groups. The influence of age on associations between types of balance performance seems to be small and differences between young adults on the one and children/adolescents on the other side may relate to the still developing postural control system of children and adolescents.

Declaration of Competing Interest

None of the authors has any conflicts of interest.

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