Normative Data Set of SWAY Balance Mobile Assessment in Pediatric Athletes

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Abstract

Objective: To examine and describe normative values for an objective, mobile measure of postural stability commonly used in concussion assessments, SWAY Balance (SWAY Medical, Tulsa, Oklahoma). **Design:** Retrospective analysis of baseline balance assessments in a healthy pediatric population. **Setting:** Baseline assessments completed by certified athletic trainers at an outpatient concussion center or sports medicine offices in Philadelphia, PA and surrounding suburban Pennsylvania and New Jersey or during an athletic trainer's baseline assessment of collegiate athletes at a National Collegiate Athletic Association (NCAA) Division-II University in Fort Lauderdale, FL. **Participants:** Test results of a sample of 466 athletes aged 5 to 18 years were included. **Interventions:** The SWAY Balance test was administered using a mobile device on all participants as part of a standard preseason, baseline evaluation, following the standard evaluation protocol. **Main Outcome Measures:** Baseline SWAY Balance mobile assessment balance and reaction time scores, age and sex effects, were examined. **Results:** Normative scores are described, with results stratified into 4 age groups (5-9, 10-12, 13-17, and 18 years old). Balance scores, overall and within each individual stance score, improved with the age of the participants. Sex effects on balance were only seen in single-leg stances, with females outperforming males. Reaction time was found to be faster in males and improved with age, peaking at 13 to 17 years old and slowing in 18-year-olds. **Conclusions:** Normative, age-specific SWAY Balance test results provided are of clinical use as references in the concussion assessments of pediatric athletes.

Key Words: concussion, balance, pediatrics, normative, assessment, reaction time

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INTRODUCTION

It is estimated that up to 3.8 million athletes suffer a sport-related concussion (SRC) injury each year.[1] Children and adolescents seem to be especially vulnerable to sustaining an SRC, because of the large number participants who take part in recreational or competitive sports.[1–3] A recent investigation determined that 54% of all concussion visits to US emergency departments were SRCs occurring in 8 to 19-year-olds.[4] Despite increasing interest from researchers and sports medicine professionals, the clinical diagnosis of concussion often remains dependent on self-reported signs and symptoms, with supporting information being derived from clinically administered test batteries.[2,5,6] Current consensus statements recommend the use of multidisciplinary evaluations and assessments to aid in diagnosing concussions.[2,5,7–10] Neurocognitive tests, balance and reaction time assessments, and visual processing tests are among the most common functional assessments used in concussion evaluations, with the process of comparing postinjury performance profiles against baseline standards generally being considered standard of care.[9–12]

Test batteries frequently used for diagnostic purposes after a concussion are often administered before the occurrence of injury as part of a preparticipation baseline screening. Baseline testing functions as an individual benchmark for comparison in the event of a suspected injury or to monitor progress during concussion recovery.[12,13] Although not widely mandated by state legislation, many school districts and sports organizations have advocated for the implementation of baseline testing as a best practice for concussion management.[13,14] Baseline testing for pediatric athletes has been suggested to occur on a yearly basis, instead of the every 2 years of recommendation generally made for teenagers and adults.[15] These recommendations may be related to the cognitive development occurring during childhood and adolescence.[15,16] In the absence of a recent baseline evaluation for a concussed child, age- and sex-specific normative scores can serve as useful clinical comparisons.[17,18]

Balance deficits are seen in nearly 30% of individuals who suffer an SRC.[2,9,19,20] Subsequently, balance testing is often used in diagnosing and managing concussive injuries.[2,9,20] There are a variety of testing methods used to assess balance clinically.[9,21] Force-plate technology is considered by many to be the "gold-standard" method of providing an objective, validated evaluation of balance. However, the standard, laboratory grade force-plate technology is expensive and cumbersome, limiting its practicality and effectiveness in some clinical settings. There are less expensive, valid and reliable, force-plate options such as the Nintendo Wii Balance Board (Nintendo, Kyoto, Japan) that may be more readily used in clinical settings.[20,22] The Balance Error Scoring System (BESS) was developed as an easy-to-use, cost-effective method of assessing balance dysfunction and is the most widely used by clinicians and researchers in evaluating balance-related issues after concussion.[20,23–25] The BESS has been reviewed as a valid and reliable balance measure in

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concussion assessment, but the test relies on video-taped analysis, the interpretation of results from individual administrators, and manual scoring of balance errors, which may negatively affect reliability.[25,26] Mobile technology developments have provided applications that seem capable of assessing balance in an objective, valid, and reliable manner.[27–29]

SWAY Balance (SWAY Medical, LLC), an alternative method of assessing balance, uses triaxial accelerometer output to measure balance through postural sway during performance of 5 stance conditions.[27,30,31] The test measures movement by collecting kinetic data from imbedded gyroscope and accelerometers of an iPad. Postural stability has been accurately quantified in previous studies of balance when using these built-in measures and was found to be conducive in characterizing a clinical, traditional test of balance (BESS). SWAY Balance has been found to have strong test–retest reliability in the adult population.[31] Lack of published normative data and undisclosed algorithms used to calculate balance scores serve as limitations to the current clinical utility of the test.

A strong, inverse correlation has been found between SWAY Balance test scores and BESS scores in a college-aged, nonathlete population.[27] This inverse relationship is explained by varying scoring methods. Balance Error Scoring System scoring is rated by number of errors, with a higher score indicating more errors and poorer balance performance, whereas higher scores on SWAY indicate better performance.[27] Recent efforts have been made to classify normative scoring on other balance assessments.[24] Further exploration of normative data for SWAY Balance testing is warranted and of clinical relevance. The Institute of Medicine's recent recommendation to "support research to establish objective, sensitive, and specific metrics and markers of concussion diagnosis, prognosis, and recovery in youth" emphasizes the importance of research establishing normative data in athlete populations at risk of concussions.[32]

The purpose of the current study was to explore and describe normative ranges of SWAY Balance test results in a healthy, pediatric population undergoing baseline evaluations. We hypothesized a range of baseline test results with higher scores being associated with increased age.

METHODS

Subjects

Records of SWAY Balance tests administered in 2014 to 2016, as part of baseline concussion assessments of athletes at a clinical, outpatient concussion center in the city of Philadelphia, Pennsylvania, at outpatient orthopedic sports medicine offices in suburban Pennsylvania and New Jersey, and at a Division-II University in Fort Lauderdale, Florida, were compiled. Athletes were included if they completed the SWAY Balance test as per the standard testing protocol and were between the ages 5 and 18 years.

Procedures

The SWAY Balance test is composed of 5 stance positions; double leg, tandem right, tandem left, single-leg right, and single-leg left, all of which produce individual component scores and are averaged to produce a total average score. A sixth component, a reaction time trial was added to the test in October, 2014.[30] Records of tests administered after this date include a sixth component score. Balance scores range from 0 to 100, with higher scores representing greater stability. A score of 100 indicates no movement sensed by the triaxial accelerometer. Reaction time is measured by a simple reaction time assessment; the entire iPad screen flashes a color change serving as the single stimulus prompting the test taker to shake the iPad to show recognition. The time between the stimulus (full-screen color change) and the test-taker response (shaking iPad) is measured as the reaction time raw score. Reaction time scores are determined from 5 trials, measured in milliseconds. The fastest and slowest trials are dropped and the average of the 3 remaining trials is converted, using a proprietary algorithm, to a 100-point scale with the fastest reaction time speed represented by 100.[30] SWAY Balance tests were administered by certified athletic trainers at all institutions using the SWAY Balance application on an iPad (Apple Computer Inc, Cupertino, California). Various generations of iPads were used to administer tests. Tests were administered following the standardized SWAY Balance protocol, that is, test takers wore athletic sneakers and completed the testing on a flat, hard surface with the test taker holding the iPad against their chest with their eyes closed. The testing protocol instructs baseline SWAY Balance tests to be administered as 3 trials following identical methods; the first trial is designed to familiarize the tester with the testing protocol. The second and third trial results are averaged to produce a baseline SWAY Balance score.

Outcome Measures

Total SWAY score and each individual stance score; double leg, tandem right, tandem left, single-leg right, single-leg left, and reaction time score were the outcome variables of interest. Subject demographics were considered as independent variables of interest.

Analysis

All analyses were conducted using IBM SPSS Statistics for Windows, version 23.0 (Armonk, NY, IBM Corporation). An alpha value of 0.05 was considered to be statistically significant. Descriptive statistics were performed to characterize participants' age by mean and SD, with sex described by frequency and percentage. The 466 participants were stratified into 4 age groups (5-9, 10-12, 13-17, and 18 years old). Age group stratification was determined to optimize statistical power while also considering practical athletic applications and academic, developmental milestones. Normative scores were described using mean, median, SD, and percentiles stratified by the age groups described above. The Shapiro–Wilk test was conducted to assess the normality of the data; however, despite the results, the sample was large enough to justify the use of parametric tests.[33] Participants who completed their testing before the addition of the reaction time component of the SWAY Balance test ($n = 77$) in October 2014 were excluded pair wise from the reaction time analyses only. These participants are included in the balance analyses, as the reaction time modules are independent of the measure of reaction time.

Multiple linear regressions were used to investigate the relationship between age, as a continuous variable, and SWAY Balance test scores. An independent-samples t test was administered to determine age differences by sex. A 2-way between-groups analysis of variance (ANOVA) was conducted to explore the effects of age group and sex on SWAY Balance test scores. The Levene test for equality of variances was used to determine if the assumption of homogeneity of variances has been violated. If there was found to be a difference in variances across groups, a stricter alpha was used to interpret the results (alpha <0.01) of the 2-way ANOVA, in accordance with recommendations by Tabachnick and Fidell (this was true in the tandem right, tandem left, single-leg right, and single-leg left stance score categories).[34,35] The Tukey post hoc analysis was conducted to further explore specific differences by age groups.

Ethical Considerations

This retrospective review of deidentified data was approved by the Thomas Jefferson University Institutional Review Board. Consents were not obtained because the study was classified as an exempt study of a preexisting, deidentified data set of test scores.

RESULTS

The 466 subjects ranged in age from 5 to 18 years, with a mean age of 14.06 ± 2.24 years. Further subject demographics are described in Table 1. Descriptive statistics, including age group–specific percentile score cutoffs for all test categories, are found in Table 2. Figure 1 illustrates linear trends of each SWAY Balance score category by age groups.

An independent-samples *t* test identified significant age differences between sexes in our sample (M_{males} = 12.64 ± 3.67, $M_{females}$ = 15.56 ± 3.41; t(464) = −8.891; $P <$ 0.0001). Multiple linear regression analyses investigated the predictive ability of test-taker age and sex on SWAY Balance test scores; results are outlined in Table 3. Age was significantly, positively associated with all individual score categories of SWAY Balance and the total average score. All 5 stance scores significantly increased with age (double leg r = 0.300, $P < 0.0001$; tandem right r = 0.375, $P < 0.0001$; tandem left r = 0.337, $P < 0.0001$; single-leg right r = 0.461, $P < 0.0001$; and single-leg left r = 0.547, $P < 0.0001$). These findings indicate that 9% to 31% of the variance in each stance score can be attributed to the linear model consisting of age and sex of the test taker. The individual regression coefficients and coefficients of determination are included in Table 3. Reaction time was also significantly associated with age (reaction time r = 0.120, $P < 0.0001$). Of additional interest, average reaction time scores were statistically significantly, positively correlated with single-leg scores for both legs (right r = 0.101, $P = 0.047$ and left r = 0.108, $P =$ 0.033).

Because of the statistically significant age differences between sexes in this sample and the significant correlation between test scores and age, *t* tests could not be used to explore sex differences in scores independent of age. Table 4 outlines 2-way, between-groups ANOVAs examining the effects of age and sex on each score category. There was no statistically significant interaction effect between sex and age group for any score category, allowing for the interpretation of the main effects of age and sex on scores individually. There were significant main effects for age, but not sex, for total score ($F_{age}(3,466) = 41.79$, $P <$ 0.0001), double leg ($F_{age}(3,466) = 13.62$, $P < 0.0001$), tandem right ($F_{age}(3,466) = 16.58$, $P < 0.0001$), and tandem left ($F_{age}(3,466) = 15.75$, $P < 0.0001$) scores, with older age associated with higher scores. Both age and sex had significant main effects on single-leg right ($F_{age}(3,466)$ = 24.97, $P < 0.0001$; $F_{sex}(1,466) = 10.92$, $P = 0.001$), single-leg left ($F_{age}(3,466) = 42.27$, $P < 0.0001$; $F_{sex}(1,466) = 8.64$, $P = 0.003$), and reaction time ($F_{age}(3, 389) = 13.97$, $P < 0.0001$; $F_{sex}(1, 389) = 11.32$, $P =$ 0.001) scores. Tukey post hoc comparisons were conducted to determine where actual group differences existed. The youngest age group (5 to 9-year-olds) scored significantly lower than the older groups in all score categories, with additional group differences between the second youngest group (10 to 12-year-olds) and the older 2 groups (13 to 17-year and 18-year-olds) in several score categories. Females outperformed males in both single-leg test stances, whereas males outperformed females in reaction time. All statistically significant age group differences are highlighted in Table 4.

The youngest age group (5 to 9-year-olds) had the lowest scores in all stance categories. Ten to 12-year-olds significantly outperformed their younger counterparts in total score, double leg, one of the single-leg score categories, and reaction time, but scored lower than the older groups in all balance assessments. The 13 to 17-year-old age group performed worse on single-leg stances than 18-year-olds but showed no significant deficits in any other balance stance. Although 18-year-olds scored the highest of all age groups on all balance stances and total score, they were significantly slower in reaction time compared with 13 to 17-year-olds.

TABLE 1. Participant Demographics

Variable	Total n (%)	Mean Age ± SD	Median
Age, y			
5-18	466 (100)	14.1 ± 3.8	14.0
Age groups, y			
5-9	61 (13)	8.3 ± 0.9	8.0
10-12	145 (31)	10.9 ± 0.8	11.0
13-17	69 (15)	14.9 ± 1.7	15.0
18	191 (41)	18.0 ± 0	18.0
Sex			
Male	240 (51.5)	12.6 ± 3.7	12.0
Female	226 (48.5)	15.6 ± 3.4	18.0

DISCUSSION

Balance testing is considered a vital part of postinjury concussion evaluations and is recommended in conjunction with neurocognitive testing and symptom assessments as part of a comprehensive approach to the diagnosis and management of SRCs.[2,9,10] Noting the importance of balance assessments in comprehensive concussion evaluations, we investigated SWAY baseline balance and reaction time scores in athletes, age 5 to 18 years old. Baseline assessments are ideal when used as a comparison once an injury is suspected; however, in the absence of an individual's baseline evaluation, many assessments allow for comparisons to be made using normative ranges.[36] Historically, the BESS has been the most widely recommended tool for

TABLE 2. Descriptive SWAY Balance Scores

	N	Mean ± SD	Median	>90th	75th	50th	25th	<10th
Total score								
5-9 years old	61	61.39 ± 10.44	62.43	75.87	69.17	62.43	52.66	46.61
10-12 years old	145	69.92 ± 9.71	70.70	81.37	75.84	70.70	63.24	56.96
13-17 years old	69	76.27 ± 8.07	75.27	88.18	82.11	75.27	70.08	67.10
18 years old	191	73.17 ± 8.96	76.84	93.00	82.52	76.84	73.05	67.77
Double leg								
5-9 years old	61	94.53 ± 7.41	97.59	99.77	99.30	97.59	92.19	81.69
10-12 years old	145	96.92 ± 3.30	98.07	99.65	99.10	98.07	95.72	92.84
13-17 years old	69	97.65 ± 2.85	98.48	99.91	99.53	98.48	97.19	93.24
18 years old	191	98.63 ± 3.54	99.60	99.97	99.90	99.60	98.90	96.50
Tandem right								
5-9 years old	61	78.11 ± 21.18	84.65	96.29	93.01	84.65	69.06	47.46
10-12 years old	145	82.52 ± 19.10	89.08	96.97	93.90	89.08	78.80	60.92
13-17 years old	69	88.95 ± 11.67	92.45	98.41	96.59	92.45	84.43	75.65
18 years old	191	93.14 ± 7.75	95.78	99.35	98.50	95.78	90.20	82.68
Tandem left								
5-9 years old	61	80.74 ± 17.66	88.19	97.26	92.77	88.19	71.27	50.22
10-12 years old	145	85.26 ± 14.17	90.11	96.93	94.66	90.11	81.55	65.12
13-17 years old	69	90.29 ± 8.42	93.14	98.60	97.21	93.14	86.40	77.81
18 years old	191	92.86 ± 9.32	96.17	99.24	98.64	96.17	90.52	82.54
Single-leg right								
5-9 years old	61	44.66 ± 31.45	51.49	84.37	72.56	51.49	10.59	0.00
10-12 years old	145	53.15 ± 26.90	59.39	85.24	75.32	59.39	33.73	10.20
13-17 years old	69	68.08 ± 23.95	76.03	90.53	85.55	76.03	56.64	32.08
18 years old	191	77.40 ± 18.45	83.29	95.15	90.95	83.29	69.39	51.72
Single-leg left								
5-9 years old	61	39.59 ± 26.35	39.47	76.52	64.71	39.47	17.32	0.00
10-12 years old	145	52.86 ± 27.44	60.49	85.67	77.58	60.49	32.65	9.74
13-17 years old	69	68.11 ± 22.15	73.82	93.10	82.60	73.82	59.04	32.46
18 years old	191	79.56 ± 16.80	82.76	95.51	91.51	82.76	73.04	58.87
Reaction time								
5-9 years old	60	54.88 ± 8.58	55.40	65.41	61.12	55.40	48.56	42.97
10-12 years old	128	63.56 ± 8.77	63.74	75.42	70.15	63.74	57.32	51.60
13-17 years old	56	65.69 ± 7.52	66.09	75.86	70.49	66.09	60.59	56.13
18 years old	145	61.19 ± 8.48	60.74	71.82	67.18	60.74	55.29	51.23

assessment of balance in relation to SRCs.[9,37] Although normative data exist, the BESS test is inherently reliant on subjective scoring and interpretation. As per the BESS protocol, all tests should also be video recorded and scored on review.[38,39] Given the impracticality of this type of administration for most medical facilities, SWAY Balance may be an objective addition in the clinical assessment of balance dysfunction. In that it minimizes the subjectivity and human error associated with the assessment of balance, future SWAY Balance studies may also be useful in further exploring sex-based differences that have been reported in the literature.[40,41] The results provided in this article represent the first objective, normative data set for SWAY Balance test scores. Normative data are important in allowing for the comparison of postconcussion test results in the absence of a baseline report.

Previous studies have found conflicting effects of sex on balance. In studies of children[24,42] and adults,[27] some researchers have found no sex effects, whereas others have found that females had superior balance compared with their male counterparts when using the modified BESS[43] and force-plate assessments.[44] The current study advances the discussion of sex-related differences in balance. Significant sex effects were found for the single-leg components of the SWAY Balance test with females outperforming males; however, no sex-related differences in double-leg or tandem stances were found. Although anatomical differences such as a lower center of gravity for women may influence single-leg balance, it is also possible that differences in core strength may explain why females in the current sample outperformed their male counterparts as was seen in previous literature that found that women exhibited greater dynamic postural

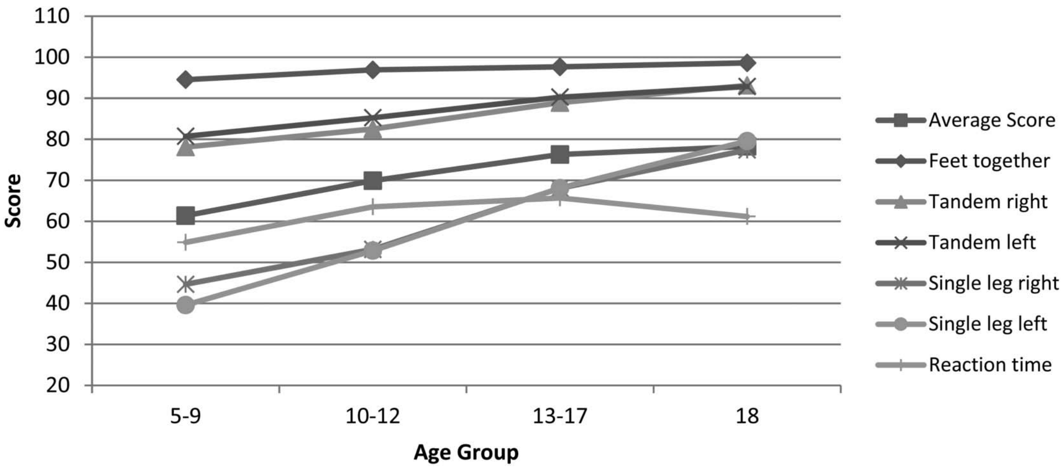

Figure 1.
SWAY Balance scores by age group.

control.[40,41] The breakdown of SWAY Balance test scores into stance-specific categories allows for additional clinical insight at postinjury. Similarly, males had faster reaction time scores compared with females, which is only evident by comparing that individual category score. This finding supports previous studies that have identified sex differences in reaction time.[36,45] The mechanisms responsible for these differences warrant further investigation but may be related to participation in fast-acting sports,[46] sex differences in muscle contraction speeds, and hormonal differences.[45] Because the proprietary scoring of SWAY has not been published, the clinical utility of SWAY may be optimized through the evaluation of the subscale categories in addition to total scores, as highlighted by current study results.

This study also identified age group differences in SWAY Balance scores. Increased age was associated with increased performance in all SWAY Balance score categories, supporting previous findings.[24,47]

In addition to anatomical changes that occur in concert with physical development (ie, height and body mass), it is possible that balance-related improvements are associated with strength and coordination changes that occur in response to athletic participation and physical training. Of particular interest in the present sample, reaction time scores were observed to peak in the 13 to 17-year-old age group and then decline slightly in 18-year-olds. A similar trend has been shown in previous studies investigating reaction time across the age span.[48,49]

The homogenous athlete sample serves as a limitation in generalizing results found to the general population because of inherent differences in balance ability between athletes and nonathletes.[50] In addition, balance ability could be affected by the type of sport played. Sport participation type or level was unavailable for the test population, but athletic experience effects on postural control should be further investigated. It is important to consider that the study population spans a large age range and likely varies in athletic participation from recreational youth participants to Division-II college athletes. Full disclosure and knowledge regarding the SWAY Balance test score algorithms may provide a further limitation to this study. Ideally, all tests would be administered on iPads of the same generation as accelerometers may have changed between generations; however, the clinical nature of the data collection limited the practicality of addressing this empirical concern. Despite this methodological limitation, the SWAY Balance application is designed for use on all versions of iPads.[30]

This study provides a summary of pediatric normative data for the SWAY Balance test. In general, the results indicate that older children perform better on SWAY Balance testing compared with younger children. Moreover, females outperform males in single-leg stances, whereas males outperform females in measures of reaction time. A breakdown of the

TABLE 3. Multiple Regression Model

	R	R^2_{model}*	*F*	*P* (2 Tailed)	β_{age}	R^2_{age}	β_{sex}	R^2_{sex}
Average score	0.521	0.27†	86.65	<0.0001	0.51†	0.22	0.02	0.00
Double leg	0.300	0.09†	23.53	<0.0001	0.28†	0.07	0.05	0.00
Tandem right	0.375	0.14†	39.19	<0.0001	0.35†	0.11	0.07	0.00
Tandem left	0.337	0.12†	31.82	<0.0001	0.30†	0.08	0.09	0.01
Single-leg right	0.461	0.23†	70.32	<0.0001	0.40†	0.14	0.16†	0.02
Single-leg left	0.547	0.31†	105.20	<0.0001	0.50†	0.21	0.13†	0.01
Reaction time	0.120	0.05†	10.89	0.003	0.20†	0.03	-0.21†	0.04

** Model: multiple regression model independent factors: age and sex.*
† Significant with $P < 0.05$.

TABLE 4. Two-Way Analysis Of Variances

	N	Mean ± SD	Sum of Squares	*df*	*F*	*P*	Partial Eta^2
Average score							
All ages	466	73.17 ± 10.92	Interaction effect				
Males	240	70.85 ± 10.66	27.27	3	9.09	0.957	0.001
Females	266	75.64 ± 10.67	Sex main effect				
5-9 years old	61	61.39 ± 10.44	42.24	1	0.487	0.485	0.001
10-12 years old*	145	69.92 ± 9.71	Age main effect				
13-17 years old*†	69	76.29 ± 8.07	10 866.99	3	41.79	<0.0001	0.215
18 years old *†	191	78.27 ± 8.96					
Feet together							
All ages	466	97.41 ± 4.31	Interaction effect				
Males	240	96.75 ± 4.22	76.07	3	1.51	0.211	0.010
Females	266	98.12 ± 4.30	Sex main effect				
5-9 years old	61	94.53 ± 7.41	3.50	1	0.209	0.648	0.000
10-12 years old*	145	96.92 ± 3.30	Age main effect				
13-17 years old*	69	97.65 ± 2.85	686.38	3	13.62	<0.0001	0.082
18 years old*†	191	98.63 ± 3.54					
Tandem right§							
All ages	466	87.25 ± 15.75	Interaction effect				
Males	240	84.19 ± 16.73	282.92	3	0.435	0.728	0.003
Females	266	90.49 ± 13.95	Sex main effect				
5-9 years old	61	78.11 ± 21.18	179.96	1	0.830	0.363	0.002
10-12 years old	145	82.52 ± 19.10	Age main effect				
13-17 years old*†	69	88.95 ± 11.67	10 781.69	3	16.58	<0.0001	0.098
18 years old*†	191	93.14 ± 7.75					
Tandem left§							
All ages	466	88.53 ± 12.95	Interaction effect				
Males	240	85.94 ± 12.43	747.92	3	1.69	0.168	0.011
Females	266	91.28 ± 12.95	Sex main effect				
5-9 years old	61	80.74 ± 17.66	94.95	1	0.643	0.423	0.001
10-12 years old	145	85.26 ± 14.17	Age main effect				
13-17 years old*†	69	90.29 ± 8.42	6970.75	3	15.75	<0.0001	0.093
18 years old*†	191	92.86 ± 9.32					
Single-leg right§							
All ages	466	64.19 ± 27.14	Interaction effect				
Males	240	56.07 ± 28.30	1947.21	3	1.154	0.327	0.008
Females	266	73.82 ± 22.95	Sex main effect				
5-9 years old	61	44.66 ± 31.45	6139.50	1	10.92	0.001	0.023
10-12 years old	145	53.16 ± 26.90	Age main effect				
13-17 years old*†	69	68.08 ± 23.95	421 410.46	3	24.97		0.141

TABLE 4. Two-Way Analysis Of Variances *(Continued)*

	N	Mean ± SD	Sum of Squares	df	F	P	Partial Eta^2
						<0.0001	
18 years old*†‡	191	77.40 ± 18.45					
Single-leg left§							
All ages	466	64.33 ± 26.99	Interaction effect				
Males	240	56.04 ± 28.44	708.19	3	0.468	0.705	0.003
Females	266	73.13 ± 22.26	Sex main effect				
5-9 years old	61	39.59 ± 26.35	4358.64	1	8.64	0.003	0.019
10-12 years old*	145	52.86 ± 27.44	Age main effect				
13-17 years old*†	69	68.11 ± 22.15	63 972.30	3	42.27	<0.0001	0.217
18 years old*†‡	191	79.56 ± 16.80					
Reaction time							
All ages	389	61.42 ± 9.04	Interaction effect				
Males	211	62.79 ± 9.28	123.75	3	0.595	0.619	0.005
Females	178	60.30 ± 8.58	Sex main effect				
5-9 years old	61	54.88 ± 8.58	784.98	1	11.32	0.001	0.029
10-12 years old*	145	63.56 ± 8.77	Age main effect				
13-17 years old*	69	65.69 ± 7.52	2906.72	3	13.97	<0.0001	0.099
18 years old*‡	191	61.19 ± 8.48					

*Significantly differed from 5 to 9-year-olds.
† Significantly differed from 10 to 12-year-olds.
‡ Significantly differed from 13 to 17-year-olds.
§ Levene test of equality of error variances violated, significance set at <0.01.

test's individual score components allows for advanced examination based on the specific age and sex of the test taker. The clinical utility of this data is elevated by the high incidence of SRCs seen in pediatrics.[51] Normative data in adult populations should be considered for future studies of balance and reaction time using SWAY Balance.

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