DEVELOPMENT OF BALANCE IN CHILDREN PARTICIPATING IN DIFFERENT RECREATIONAL PHYSICAL ACTIVITIES

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Original article

Abstract

Balance, an important motor coordination ability, underlies the performance of various motor skills and allows for participation in common childhood activities. Research indicates that sport participation could support balance development in children. To confirm the above effect, this study investigated whether participation in different recreational physical activities could induce differences in children's balance ability. Specifically, 138 children, 5-11 years old (M_{age}=8.4±1.3), classified into four groups according to the activity they took part in (basketball, track and field, rhythmic gymnastics, contemporary dance), were assessed by the balance subset of the KörperKoordinationstest für Kinder. Pearson correlations were applied to detect associations of balance scores with age, height, body mass index (BMI) and showed significant correlations for BMI (p< .001). The analyses of covariance (covariate: BMI) that were computed on children's balance scores showed statistically significant effects of group (p< .001). Sidak post hoc tests indicated that children participating in rhythmic gymnastics surpassed all three other groups; whereas those taking part in basketball had the lowest scores in almost every balance item. It seems that the type of physical activity a child participates in could be a significant contributor to the development of his/her balance. Physical activities encompassing the execution of various balance tasks, such as rhythmic gymnastics, seem to offer children greater opportunities to make improvements in this area compared to children engaging in activities of low balancing requirements. This finding highlights the potential that is available to coaches: they can contribute to children's balance development by implementing sport-specific programs that target this human ability.

Keywords: motor coordination, balance, sport participation, rhythmic gymnastics.

INTRODUCTION

Motor Coordination (MC), a general construct addressing multiple abilities, underlies the development of fundamental motor skills and specialized motor skills (Vandorpe et al., 2012a); it is thus of vital importance for human motor development (Savelsbergh, Davids, Van Der Kamp, & Bennett, 2003). During childhood, the gradual maturation of the nervous system along with the provision of appropriate training stimuli is thought to influence MC (Lima, Bugge, Pfeiffer, & Andersen, 2017) and consequently result in successful motor learning (Hirtz, & Starosta, 2002). Importantly, as indicated by longitudinal research, supporting the development of MC contributes to the prevention of subsequent motor delays and favours

participation in physical activity (PA) (de Souza et al., 2014; Henrique et al., 2018; Lopes, Rodrigues, Maia, & Malina, 2011). Additionally, there is consistent evidence showing that a high MC level predicts athletic success both in childhood (Vandorpe et al., 2012a) and adolescence (Pion et al., 2015a).

A distinct ability within the MC construct is balance (Hirtz, 1985). Balance is responsible for the maintenance or recovery of the body's center of mass within the body's base of support to prevent falling and complete the required movements (Shumway-Cook, & McCollum, 1991). The importance of its development is profound, considering that it is thought to be an integral part of the performance of all movements (Westcott, Lowes, & Richardson, 1997). The development of both static and dynamic balance in children facilitates the performance of a wide range of locomotor and object control skills (Shumway Cook, & McCollum, 1991; Ulrich, & Ulrich, 1985); therefore, it is fundamental for common childhood activities, such as play, schooling (Franjoine, Darr, Held, Kott, & Young, 2010; Kolic, O'Brien, Bowles, Iles, & Williams, 2020) and also for participation in any sport (Ricotti, 2011).

The development of general MC and balance in childhood is affected by both individual and environmental parameters. To start with gender, conflicting findings have been published, with boys and girls found to either present equal MC levels (Henrique et al., 2018; Söğüt, 2016) or demonstrate differences in relation to the different abilities/tasks examined by the MC tests (Freitas et al., 2015; Vandorpe et al., 2011). Specifically for balance, existing evidence shows, on one hand, the absence of differences between genders (Freitas et al., 2015; Söğüt, 2016) and on the other the superiority of girls compared to boys (D'Hondt et al., 2011; Lima et al., 2017; Vandorpe et al., 2011). Nevertheless, several researchers attribute the above differences between boys and

girls to the discrete gender roles imposed by society (Al-Haroun, 1988; Du Toit, & Pienaar, 2002), since it has been suggested that compliance with these roles could influence the motor performance of children (Malina, 2004). In reference to weight status, findings are largely consistent across studies, revealing the negative association of BMI with MC (Antunes et al., 2015; Bardid, Rudd, Lenoir, Polman, & Barnett, 2015; D'Hondt et al., 2011, 2013; Henrique et al., 2018; Lima et al., 2017; Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012) and particularly balance (Antunes et al., 2015; Bardid et al., 2015; D'Hondt et al., 2011, 2013; Franjoine et al., 2010; Kolic et al., 2020), underlining the fact that weight management can influence, to some extent, children's MC and balance development. As far as the age effect is concerned, it seems that MC and balance improve during the preschool years (Venetsanou, & Kambas, 2011), but during childhood remain either relatively stable (D'Hondt et al., 2013; Lopes et al., 2011; Vandorpe et al., 2012b) or, according to other researchers, improve (Antunes et al., 2015; Bardid et al., 2015; Henrique et al., 2018; Kolic et al., 2020; Söğüt, 2016). Regarding the latter, it has been advocated that children who undergo regular sports training develop a higher general MC level than children who do not participate (Vandorpe et al., 2012b) or partially participate (spending fewer hours) in PA and sport (Fransen et al., 2012; Graf et al., 2004; Opstoel et al., 2015; Vandorpe et al., 2012b).

To further confirm the positive effect of sport participation and therefore highlight the contribution of this environmental parameter to MC development, some researchers have attempted to investigate the potential effect the different types of sport could have on the development of MC in youth (Jaakkola, Watt, & Kalaja, 2017; Opstoel et al., 2015; Pion, Fransen, Lenoir, & Segers, 2014; Pion et al., 2015b). From

their findings, it can be assumed that regular engagement in a specific sport may be responsible for differences in MC, indicating that some types of sport are more effective in improving MC than others. Specifically for balance, the above studies show that engagement in certain sports, such as gymnastics, offers children the opportunity to better develop their balance in comparison to other sports, such as basketball, badminton, martial arts (Jaakkola, Watt, & Kalaja, 2017; Opstoel et al., 2015), handball, soccer, volleyball, table tennis (Pion et al., 2015b), swimming or ice hockey (Jaakkola, Watt, & Kalaja, 2017). However, most of these studies focus on highly trained adolescent athletes, leaving it unclear whether participation at a recreational level could be a sufficient stimulus to induce improvements in the balance ability of children. Therefore, the purpose of this study was to examine whether children who regularly participate in one of four different types of recreational PAs (basketball, track and field, rhythmic gymnastics, contemporary dance) present differences in the development of balance. It was hypothesized that (a) children participating in the above PAs would not develop balance at an equal level, mainly as a result of the different training stimuli they have received, and (b) children engaging in rhythmic gymnastics, a PA of high balancing demands, might be more capable in motor tasks that require balance comparing to children engaging in the other PAs.

METHODS

For this study, 138 children, aged 5-11 years (M_{age}=8.4±1.3, 44.2% boys, M_{weight}= 31.7kg±7.7, M_{height}=1.30m±.09, M_{BMI}=18.5±3.4), participating in four different types of recreational PAs, i.e. basketball (n=36), track and field (n= 32), rhythmic gymnastics (n= 34) and contemporary dance (n=36), were recruited from local sport clubs in Athens, Greece,

and were classified into four respective groups. Participants' engagement in their PA was regular, ranging from two to four 60-minute sessions per week. During the period of data collection, none of the participants was enrolled in any other PA program. Prior to data collection participants' parents and legal guardians were informed about the purpose and the procedures of the research and were asked to submit their written consent. Each participant's verbal approval was also required.

Balance. The KörperKoordinationstest für Kinder (KTK; Kiphard, & Schilling, 1974, 2007) is a reliable test battery (Kiphard, & Schilling, 2007; Vandorpe et al., 2011), developed to measure, in four relative subsets, the gross MC of children and adolescents (5-15-year-old). In this study, participants' balance was assessed by the respective subset within KTK, which includes three similar tasks addressing the dynamic balance. For their assessment, the examinees were asked to walk backwards on three balance beams of decreasing width, i.e. 6cm, 4.5cm and 3cm. The length of each beam was 3m and its height 5cm. Each task was performed three times. Examinees' assessment was based on the number of successful steps they managed to take to complete each task. The highest score for each is eight successful steps. Scores on each balance beam were recorded (maximum of 24) and then added up to generate the balance subset score (maximum of 72).

Anthropometry. Measurements of anthropometry included: (a) participants' stature at the nearest 0.5m obtained by a portable stadiometer (Seca 217), (b) participants body mass at the nearest 0.1kg measured by a digital scale (Seca 899) and (c) BMI calculations using the body mass(kg)/height(m^2) formula. According to the International Obesity Task Force (IOTF) gender- and age-specific cut-off criteria (Cole, Bellizzi, Flegal, & Dietz, 2000), participants of this study were

classified into three BMI categories (normal weight, overweight and obese).

Data were collected from May to July 2019 at the facilities provided by each sport club. Before the examination of the balance tasks, the anthropometric characteristics were recorded. During the measurements of stature and body mass, the examinees were barefoot and lightly dressed. The familiarization and examination procedures for the balance tasks were conducted in reference to the KTK manual guidelines (Kiphard & Schilling, 2007). According to these, each child was assessed individually by experienced examiners.

Initially, data were screened for normality and outliers, and descriptive statistics (M, SD) were calculated. The percentages (%) of normal weight, overweight and obese participants were also computed. Pearson correlation coefficients were then applied to detect the potential associations of balance scores with age, height and BMI. Given the observed correlation of BMI with balance

scores, BMI was defined as a covariate, and a univariate analysis of covariance (ANCOVA) was then performed on the participants' total balance subset score to examine potential differences among the four groups. To obtain a more detailed picture of the collected data, a multivariate analysis of covariance (MANCOVA) was also conducted on the three balance items scores. The application of Sidak post hoc tests followed both analyses. Significance level was set at p<.05. For the interpretation of the results, effect sizes (eta-squared, η^2) were calculated and reported for all analyses. In this study, effect sizes above $\eta^2 > .14$ were considered important (Cohen, 1988). Data were analysed by the IBM SPSS 25.0 software package.

RESULTS

Descriptive statistics of participants' age and anthropometric characteristics stratified by group are summarized in Table 1.

Table 1

Descriptive statistics for age, anthropometric characteristics and percentages (%) of BMI categories stratified by group.

	Basketball (36)	Track and field (32)	Rhythmic Gymnastics (34)	Contemporary dance (36)
Age	8.6±1.3	8.5±1.3	8.3±1.2	8.2±1.3
Weight	34.3±9.3	31.2±7.9	29.6±7.2	31.6±6.3
Height	1.30±0.1	1.24±0.1	1.32±0.1	1.35±0.1
BMI	20.2±4.8	20.0±3.0	16.6±2.2	17.2±2.2
Normal weight[a]	44.4%	37.5%	88.2%	83.3%
Overweight	22.2%	50.0%	11.8%	16.7%
Obese	33.3%	12.5%	-	-

[a] Classification of BMI categories according to IOTF gender- and age-specific cut-off criteria (Cole et al., 2000)
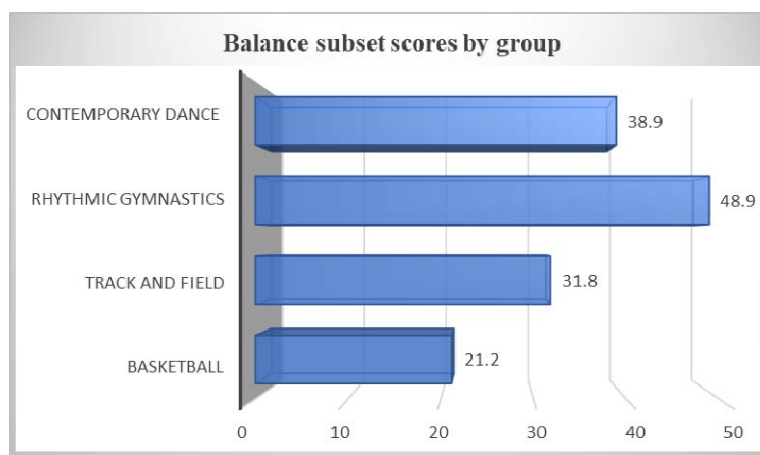
Figure 1. Balance subset scores of participants by group.

Table 2
Estimated Marginal Means, Std. Errors, F ratios, p and η² values for balance subset score and each balance task score stratified by group.

	Basketball	Track and field	Rhythmic Gymnastics	Contemporary dance	Type of Activity		
					F	p	η²
Balance Subset Score (step counts)	21.2± 1.9	31.8± 2.0	48.9± 1.9	38.9± 1.8	34.173	.0001	.082
6cm balance score (step counts)	11.5± 0.8	16.0± 0.9	20.8± 0.9	19.1± 0.8	20.595	.0001	.317
4.5cm balance score (step counts)	6.2± 0.8	11.0± 0.8	19.0± 0.8	13.5± 0.8	38.307	.0001	.464
3cm balance score (steps counts)	3.6± 0.6	4.8± 0.6	9.1± 0.6	6.3± 0.6	13.061	.0001	.228

As it can be seen in Table 1, in respect of BMI, a high percentage of participants in this study were overweight (24.6%) and obese (11.6%). Both basketball and track and field groups presented the highest percentages of overweight and obese children (55.5% and 62.5%, respectively); whereas rhythmic gymnastics and contemporary dance group had the highest percentages of normal weight children (88.2% and 83.3%, respectively). No obese children were found among the participants in the latter activities.

Correlations of both the balance subset score and the score of each balance task with age, height and BMI indicated that only BMI was significantly associated with balance scores, presenting negative values ranging from $r= -.34$ to $-.51$ ($p=.0001$) *(balance subset score: r=-.48, 6cm balance beam: r= -.51, 4.5cm balance bean: r= -.42, 3cm balance beam: r= -.34).*

ANCOVA's results showed that, after adjusting for BMI ($F=11.916$, $p=.001$, $η²=.082$), significant differences were detected among the four groups

(F=34.173, p<.0001, η^2= .435) (Figure 1). As it was indicated by Sidak post hoc tests, on one hand, participants of rhythmic gymnastics were significantly different from participants in all other groups as they obtained the highest total balance subset scores; on the other, participants of the basketball group also significantly differed from all others as they received the lowest respective score. No other statistically significant differences were observed (p<.05) (Table 2).

According to MANCOVA's results, BMI proved to be a significant covariate (Pillai's trace= .120, F=5.954, p= .001, η^2=.120). After adjusting for BMI, group was found to be both statistically significant and practically important (Pillai's trace=.540, F=9.736, p<.0001, η^2=.180). The univariate analyses that followed showed that the covariate was significant both for the 6cm and 4.5cm balance score. Also, the effect of group was significant and practically important for all three balance task scores (p<.05) (Table 2).

Sidak post hoc tests uncovered the following differences: (a) on the 6cm balance beam, participants of rhythmic gymnastics scored higher than all other groups, but differed statistically significantly only from those in the basketball and track and field groups, not from those engaged in contemporary dance; at the other end, participants in the basketball group received the lowest scores and differed statistically significantly from all the others; (b) on the 4.5cm balance beam, participants of rhythmic gymnastics and basketball, who obtained the highest and the lowest scores respectively, were statistically significantly different from participants in the other two groups, whereas participants in the contemporary dance and the track and field groups, which posted similar results, scored significantly better than those engaged in basketball, and (c) on the 3cm balance beam, participants of rhythmic gymnastics statistically significantly surpassed all

other groups, while participants in the basketball group had the lowest score and differed from those engaged in both rhythmic gymnastics and contemporary dance (p<.05) (Table 2).

DISCUSSION

The positive consequences of developing MC in childhood are well documented (de Souza et al., 2014; Henrique et al., 2018; Lopes et al., 2011; Vandorpe et al., 2012a). Substantial evidence indicates that participation in sport could lead to relative improvements and support MC development (Fransen et al., 2012; Graf et al., 2004; Opstoel et al., 2015; Vandorpe et al., 2012b). However, it is likely that each sport impacts MC, balance included (Jaakkola et al., 2017; Opstoel et al., 2015; Pion et al., 2014; Pion et al., 2015b), differently. Potential differences in balance associated with the sport type further support the role of environment and therefore the role of coaches in designing, in line with their sport's objectives, effective programs to enhance the development of this ability in children.

Exploring this perspective, the present study examined if children participating in four different types of recreational PAs, i.e. basketball, track and field, rhythmic gymnastics and contemporary dance, present differences in their balance ability. As it was initially hypothesized, the main finding of the present study is that children of different training backgrounds differ in their balance ability, indicating that the type of PA could be more or less effective in improving children's balance. The major implication of this finding is that, contrary to the claim that MC is stable during childhood (D'Hondt et al., 2013; Lopes et al., 2011; Vandorpe et al., 2012b), we are led to assume that MC could be subject to changes imposed by environmental parameters, such as participation in PAs. This is in agreement with a bulk of studies reporting that MC is not a stable condition

but, on the contrary, increases as children grow (Antunes et al., 2015; Bardid et al., 2015; Henrique et al., 2018; Kolic et al., 2020; Söğüt, 2016).

The review of literature shows that relevant studies are very few; however, they report similar results. Among them, the only study that refers particularly to children is that of Opstoel et al. (2015), which attempted to examine, among other personal characteristics, the MC abilities, as addressed in KTK, among children aged 9 to 11 years participating in 25 different sports. Participants' engagement in their sport was regular, however, its frequency per week varied from 1 to 5 hours (or more). The results showed that there were differences in the scores of children both in general MC and balance. Similarly, in the study of Jaakkola et al. (2017), which investigated the potential differences in MC in adolescent athletes participating at a competitive level in artistic gymnastics, swimming and ice hockey, it was found that the athletes in each sport obtained different scores in KTK tests, including balance. Likewise, according to Pion et al. (2015b), adolescent elite athletes participating in nine sports, including ball sports, racquet sports, martial arts, triathlon and gymnastics, demonstrated differences in their balance ability. Interestingly, as it was revealed in the study of Pion et al. (2014), relative differences were also reported among highly trained adolescents participating in sports with similar characteristics, i.e. taekwondo, judo, and karate.

However, in most of the above studies (Jaakkola et al., 2017; Pion et al., 2014; Pion et al., 2015b), participants were mainly adolescents or older children, who competed at an elite level or had an intensive training background. Inversely, the present study included participants of a different age range, including younger children (5-11-year-old) who do not participate in sport at a competitive level. Therefore, this study extends the existing knowledge on the specific topic,

confirming that regular participation in sports, even at a recreational level, can play a role in improving balance in young children, provided that balance is prioritized in their training programs.

In line with the second hypothesis of this study, rhythmic gymnastics' training, which prioritizes the execution of many balancing tasks, was far more effective in improving children's balance in comparison to the other PAs. Additionally, participation in contemporary dance, a PA which also requires balance, led to some improvements - greater improvements than those achieved by participants in basketball, but not significantly different from the improvements associated with track and field. Among the four recreational PAs which were examined in the study, basketball was the least effective in developing the ability of balance in its participants, probably due to the fact that in basketball balancing requirements are lower than in the other three activities and, therefore, respective training usually does not target balance. Concerning the three balance tasks, respective results were not very different from the overall results for balance. The general finding from the analysis of each task is that children engaging in rhythmic gymnastics demonstrate a higher balance level than children engaging in all other PAs, further highlighting the contribution of rhythmic gymnastics to the development of balance in children.

Similarly, the relevant study of Opstoel et al. (2015) showed that children who regularly participated in gymnastics (e.g., artistic gymnastics, acrobatics) received higher scores in the KTK's balance test, compared to children participating in many other sports, such as basketball, soccer, volleyball, martial arts, tennis, swimming or dance. However, in contrast to the present findings, Opstoel et al. (2015) reported that participants of rhythmic gymnastics and track and field received similar scores in balance. The reason for this discrepancy is probably the

different level of children's engagement with track and field. Gymnasts' superiority in balance was also noted in the report by Jaakkola et al. (2017) - it revealed that gymnasts scored better in the KTK test in comparison to swimmers and ice hockey players; and in the report by Pion et al. (2015b) which found gymnasts to be better in balance than athletes engaging in badminton, basketball, handball, judo, soccer, table tennis, triathlon or volleyball. It should be noted that in the above studies athletes in artistic, not rhythmic, gymnastics were compared to athletes in other sports. However, since children's improvement in balance is equally important for all types of gymnastics, it can be assumed that, similarly to artistic, rhythmic gymnastics could also be more effective in enhancing children's balance than the sports mentioned above. Moreover, in agreement with the results of the present study, both in the reports by Opstoel et al. (2015) and Pion et al. (2015b), basketball was associated with the lowest balance score comparing to the variety of other sports that were examined. At this point, it is prudent to acknowledge that in the aforementioned reference studies which assessed gymnasts of artistic gymnastics the utilization of the KTK's balance beam test may have favoured better performances in these participants, since this test simulates part of their practice. Therefore, their results should be interpreted with caution. However, for the present study this should not be considered a limitation, since participants in rhythmic rather than artistic gymnastics were assessed.

As many researchers suggest, BMI is another parameter that affects balance (Antunes et al., 2015; Bardid et al., 2015; D'Hondt et al., 2011, 2013; Henrique et al., 2018; Lopes et al., 2012; Lima et al., 2017). BMI in this study was found to be negatively correlated with children's balance; thus, group differences on balance were examined after the removal of the effect of BMI, since it was not among the purposes of this study to investigate potential differences in children' balance across the three BMI categories. However, the correlation among BMI and balance scores are in line with literature findings, which suggest that overweight and obese children receive lower scores in balance tests than normal-weight children (Antunes et al., 2015; Bardid et al., 2015; D'Hondt et al., 2011; 2013; Franjoine et al., 2010; Kolic et al., 2020). Therefore, apart from the opportunities for childen to develop their balance through sport participation, the maintenance of a healthy weight is also important for MC and balance development.

Although this study confirms the role the participation in recreational PA could play on the development of balance in children, it has certain limitations. In particular, children's previous experience with the activity (years of training) was not taken into consideration, and the cross-sectional design of the study did not capture the potential longitudinal nature of this effect. A more detailed picture of how balance is influenced by participation in different PAs would be obtained if additional and more diverse activities were examined. Furthermore, it would be useful for future research to investigate the effect of additional parameters, such as gender. Lastly, it needs to be clarified that by using KTK' balance beam test in this study, the dynamic not static balance was assessed.

CONCLUSION

The type of PA a child regularly participates in, even at a recreational level, could be a significant contributor to the development of his/her balance ability. PA that encompasses the execution of a variety of balance tasks, such as rhythmic gymnastics, seems to offer children a greater opportunity to make improvements in this area in comparison to children who engage in PA of low balancing requirements, such as basketball. The confirmation of the positive effect of this

environmental parameter has implications for coaches of young children as it highlights their potential to contribute to the development of children's balance through the implementation of sport-specific programs that target, among other things, this essential human ability. This further means that during childhood, participation in PAs should not only be about learning sports techniques but also about providing children with multiple opportunities to develop a wide base of movement skills as well as the entire spectrum of MC abilities. In this way, children would be equipped to confidently and safely engage in different PAs and sports and thus demonstrate a high level of physical literacy.

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