DOI: 10.4025/jphyseduc.v29i1.2936

Original Article

CONTROLE POSTURAL DE ATLETAS COM DIFERENTES GRAUS DE DEFICIÊNCIA VISUAL

POSTURAL CONTROL IN ATHLETES WITH DIFFERENT DEGREES OF VISUAL IMPAIRMENT

Claudemir do Nascimento Santos[1], **Thiago Lemos de Carvalho**[1], **Lilian Ramiro Felício**[2], **Míriam Raquel Meira Mainenti**[3] and **Patrícia dos Santos Vigário**[1]

[1]Centro Universitário Augusto Motta, Rio de Janeiro-RJ, Brasil.
[2]Universidade Federal de Uberlândia, Uberlândia-MG, Brasil.
[3]Escola de Educação Física do Exército, Rio de Janeiro-RJ, Brasil.

RESUMO
O objetivo do estudo foi descrever o controle postural na posição ereta semiestática de atletas com diferentes graus de deficiência visual e verificar se existem diferenças de acordo com a modalidade esportiva praticada. Participaram deste estudo seccional 22 atletas com perda total da visão (classificação funcional B1) e 17 com baixa visão (classificação funcional B2 e B3) das modalidades judô (n=17), goalball (n=12) e futebol de cinco (n=10). O controle postural foi investigado utilizando uma plataforma de força, sendo calculadas a área da elipse de 95% de intervalo de confiança (mm^2) e a velocidade média de deslocamento (mm/s). A tarefa postural foi realizada com os pés unidos e olhos fechados e vendados. Atletas com perda total da visão apresentaram menores valores para área de oscilação (p=0,02) em relação aos atletas com baixa visão. Na comparação quanto à modalidade esportiva, foi possível observar que os atletas de goalball oscilaram menos e apresentaram menor velocidade de deslocamento que os atletas de judô. Em paralelo, os jogadores de futebol de cinco foram aqueles que apresentaram melhor controle postural. As diferenças encontradas no controle postural de atletas com deficiência visual parecem estar associadas ao grau de perda visual e às especificidades das modalidades esportivas.
Palavras-chave: Transtorno da visão. Equilíbrio postural. Plataforma de força.

ABSTRACT
The aim of this study was to describe postural control in athletes with different degrees of visual impairment in erect semi-static position and verify whether it differs with sport modalities. Twenty-two athletes with total loss of vision (functional classification B1) and 17 with partial loss of vision (functional classification B2 and B3) were included in this cross-sectional study. Their sport modalities were judo (n = 17), goalball (n = 12) and five-a-side football (n=10). Postural control was investigated on a force platform with athletes in bipedal stance with eyes closed and blindfolded. The elliptical area of 95% confidence interval (mm^2) and the mean displacement velocity (mm/s) were calculated. Athletes with total loss of vision presented smaller oscillation area values (p = 0.02) when compared to athletes with partial loss of vision. Considering sport modality, five-a-side athletes were found to present the best postural control. Moreover, goalball athletes oscillated less and presented a lower mean displacement velocity in relation to judoists. The differences found in postural control in visually impaired athletes seem to be associated with the degree of loss of vision and specificities of each sport modality.
Keywords: Visual impairment. Postural balance. Force platform.

Introduction

About 285 million individuals are estimated to be visual impaired in the world[1]. Visual impairment includes blindness and partial loss of vision, both of which generally pose great challenges to both the affected individuals and society. Sport practice is a resource increasingly used with visually impaired individuals for physical and emotional rehabilitation, as well as for socialization, self-esteem improvement, and more recently, high sport performance[2-4].

Among the sports commonly practiced by the visually impaired are five-a-side football, goalball and judo[5]. For a fairer competition, all athletes undergo a functional sport classification that takes the degree of visual impairment into account[6]. Thus, the athletes can be classified as B1 (total loss of vision, B standing for blind) or B2 or B3 (partial loss of vision) [7].

In non-visually-impaired athletes, there is evidence that static and dynamic postural balance vary with sport modality[8,9]. Hrysomallis[8], for example, has demonstrated in a revision of sectional studies that gymnasts have a better balance capacity than football players, swimmers, non-athlete active individuals and basketball players, presenting smaller oscillation area and displacement velocity from the center of pressure under the feet on a force platform.

Studies demonstrate that visually impaired goalball players present better postural control than non-athlete players, but poorer than non-impaired individuals[10,11]. Similar results have been reported for judo athletes; however, without any significant difference between visually able and visually impaired judoists. This fact indicates a possible positive effect of sport practice on postural balance in visually impaired athletes[12]. Nevertheless, the correlation between postural balance, the practice of different modalities of sports and the athlete's visual impairment functional classification has been little investigated. It is important to point out that the visual system, together with the vestibular and somatosensory systems, plays an important role in the determination of postural control[13]. Information captured by these systems is integrated in the central nervous system so that adjustments can be made to maintain both static and dynamic posture[13]. Thus, the absence or deficiency of an important component such as vision may compromise balance despite possible compensatory strategies from the other systems[14,15].

Knowledge of postural balance in visually impaired athletes has relevant practical applicability. A poor postural control is associated with an increased risk of lesions, especially in the lower limbs, such as the ankle joint[16]. Athletes are a group vulnerable to lesions[17] and visual impairment contributes to increase this risk[18].

Therefore, after identifying the groups with greater postural oscillation, preventive and rehabilitation measures can be adopted to minimize possible lesions associated with reduced postural control. Another important aspect is planning of training where the inclusion of stimuli such as neuromuscular and proprioceptive stimuli may be used to improve sport performance[16].

Thus, the objective was to describe postural control in athletes with varying degrees of visual impairment in erect semi-static position and verify whether there are differences in postural control among the sport modalities: five-a-side football, goalball and judo. The hypotheses are: 1) athletes with total loss of vision have better postural control than athletes with partial loss of vision, possibly due to the development of compensatory strategies to the absence of the visual component in the former and 2) five-a-side football athletes present better postural control because it is practiced exclusively by individuals with total loss of vision. In relation to the sport modalities practiced by athletes with total and partial loss of vision, goalball athletes are expected to have a better postural control than judoists. This expectation is based on the characteristics specific to this sport modality, such as blind-folded practice, which may contribute to more efficient postural adjustments in the long run.

Methods

Participants

This observational sectional study recruited 39 visually impaired athletes functionally classified as B1 (total loss of vision), B2 or B3 (partial loss of vision) and who practiced any of the following sport modalities: judo (n=17), goalball (n=12) and five-a-side football (n=10). For analysis sake, athletes with functional classification B2 and B3 were considered as belonging to the same group despite their different degrees of loss of vision, because they receive some sort of visual information. The athletes were from the sport teams of the State of Rio de Janeiro, Brazil and participated in regional and national level competitions.

The study inclusion criteria were male or female visually impaired athletes aged 18 or older, currently practicing their sport modality for at least six months and giving their written informed consent. Athletes who had auditory and/or vestibular system alterations, who practiced more than one sport modality and who had a history of musculoskeletal lesion in the last three months that might interfere with the performance of the study procedures were excluded from the study.

The study was submitted to and approved by the Institutional Research Ethics Committee (CAAE: 31778614.0.0000.5235).

Procedures

Demographic and sport training information

The participants responded a questionnaire on sports practice, health-related life habits, musculoskeletal lesion history and their visual impairment either in writing or verbally, depending on their degree of impairment. Total body mass (TBM, kg, scale, Filizola; 100 g, Brazil) and height (H, m, stadiometer, Filizola, 0.1 cm, Brazil) were determined for the calculation of the Body Mass Index (BMI, kg/m^2).

Semi-static Postural Balance

Postural control in erect position was evaluated using a force platform (AccuSwayPLUS, AMTI, USA). The participants stood with both feet together at the body medial line with arms relaxed beside the body and with the head in neutral position (at eye height, without adjustment by the evaluator) for 35 s for measurement of stabilometer data. Measurements were performed in triplicate with 2-min intervals. The mean value was used in the analysis. All the study participants were blindfolded. The center of pressure (CoP) was calculated using the soil reaction forces determined on the force platform at an acquisition rate of 100 Hz. The initial 5 s of each attempt were considered an adaptation period and, therefore, were not considered in the analysis[19]. The CoP signal was filtered with a second-order low-pass Butterworth filter with cutting frequency of 2.5 Hz used in the direct and reverse directions. For analysis sake, the elliptical area of 95% confidence interval (area in mm^2) and the mean displacement velocity (velocity in mm/s)[20] were computed as these variables are the most frequently used in the literature in the area[21,22]. The poorest postural balance capacity was characterized by the greatest area and velocity values.

Statistical analysis

The data exploratory analysis was performed by calculating the median and the minimum and maximum values of the numerical variables and the relative frequency of the categorical variables. The box-plot approach was also used for the median (bold horizontal line), 1st and 3rd quartiles (box ends) and lower and upper limits (whiskers) and outliers (· and *). Given the sample size of each sport modality subgroup, we decided to use nonparametric analysis procedures. The results of athletes with total loss of vision (functional classification B1) and with partial loss of vision (functional classifications B2 and B3) were compared using the *Mann-Whitney* test and the sport modalities using the *Kruskall Wallis* test. Pairwise differences were identified using the *Mann-Whitney* test and adjusted using the *Bonferroni* correction ($p<0.017$). The categorical variables were compared with Fisher's exact test. A 5% statistical confidence level was used and the analyses were performed using Statistical Package for the Social Sciences (SPSS) version 17.0.

Results

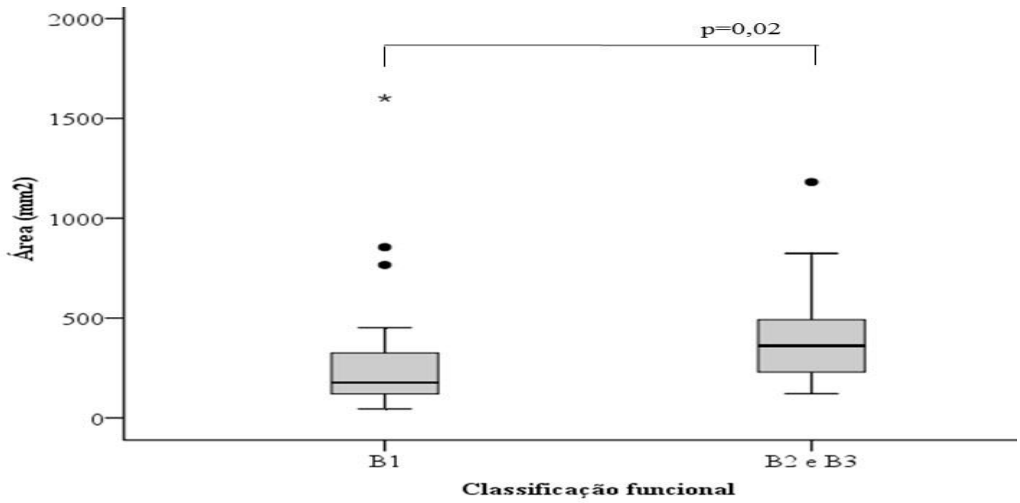
The sample was formed mostly by male athletes (74.4%). All the five-a-side football players were classified B1 and most of the judo and goalball athletes were classified B2 or B3. The subgroups were similar for age, TBM and BMI and the variables related to sport training (all p-values>0.05). The demographic and sport practice-related characteristics are presented in Table 1.

Table 1. Demographic and sport training characteristics of the study participants according to the sport modality practiced

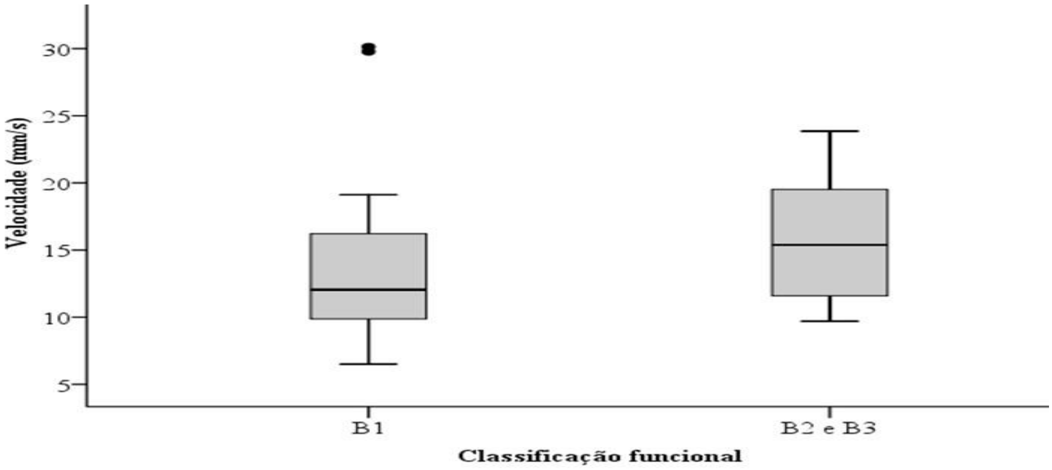
	Five-a-side Football (n=10)			Goalball (n=12)			Judo (n=17)			p-value
	Md	Min	Max	Md	Min	Max	Md	Min	Max	
Age (years)	27.5	18.0	38.0	28.5	19.0	40.0	23.0	18.0	33.0	0.12
TBM (kg)	72.3	50.0	94.8	82.4	59.6	120.1	77.3	53.1	149	0.29
BMI (kg/m²)	25.9	17.5	32.8	27.6	21.7	41.2	27.2	21.2	43.8	0.36
Training/week	5.0	3.0	5.0	4.5	2.0	6.0	5.0	3.0	6.0	0.32
Years of practice	7.0	3.0	21.0	4.0	1.0	19.0	7.0	2.0	22.0	0.06
	Percentage			Percentage			Percentage			
Male (%)	100.0			58.3			70.6			0.08
FC B1	100.0			41.7			41.2			<0.01

Note: Md=median; Min=minimum value; Max=maximum value; TBM=total body mass; H=height; BMI=Body Mass Index; FCB1=B1 functional classification (total loss of vision). *p-value calculated with Fisher's Exact Test for the categorical variables and Kruskall Wallis test for the numerical variables; statistical significance when p<0.05
Source: Authors' data

Comparison of the groups for functional class showed that the athletes with total loss of vision (B1) had a smaller displacement area in relation to the athletes with partial loss of vision (B2 and B3) (Graph 1) and no statistical difference in relation to mean displacement velocity, despite the lower median value of B1 athletes (Graph 2).



Graph 1. Elliptical area of 95% confidence interval in mm^2 of visually impaired athletes who participated in the study according to their functional classification
Note: B1 = Total loss of vision, B2 and B3 = partial loss of vision. The graph values represent the median (bold horizontal line), 1st and 3rd quartiles (box ends), lower and upper limits (whiskers) and outliers (· and *). Area (mm2), Functional Classification, B2 and B3, p=0.02
Source: Authors' data

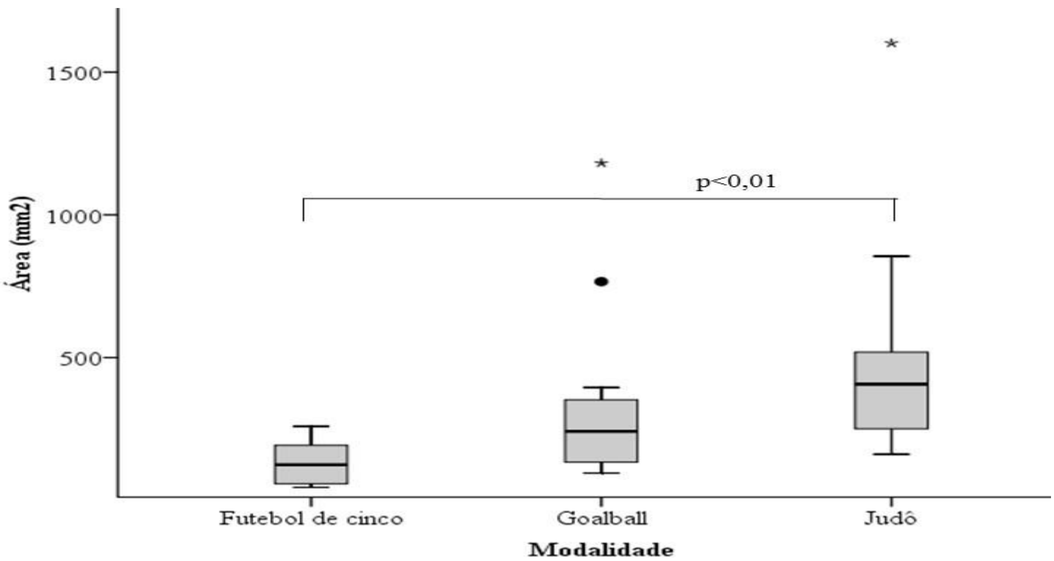


Graph 2. Mean displacement velocity in mm/s of visually impaired athletes who participated in the study according to their functional classification

Note: B1 = Total loss of vision, B2 and B3 = partial loss of vision. The graph values represent the median (bold horizontal line), 1st and 3rd quartiles (box ends), lower and upper limits (whiskers) and outliers (·). Velocity (mm/s), Functional Classification, B2 and B3

Source: Authors' data

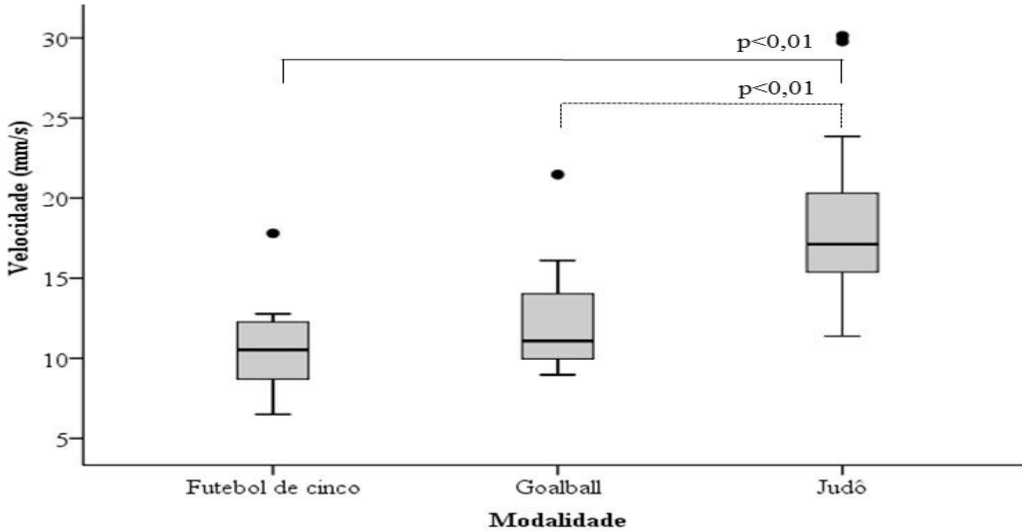
Graphs 3 and 4 present the elliptical area of 95% confidence interval and the mean displacement velocity, respectively, of the participants according to their sport modality. The five-a-side football players presented area ($p<0.01$) and displacement velocity values lower than those of the judoists. The goalball players also differed from the judoists in velocity ($p<0.01$) and presented smaller median area values, but with no statistical difference.



Graph 3. Elliptical area of 95% confidence interval in mm^2 of visually impaired athletes who participated in the study according to their sport modality

Note: The graph values represent the median (bold horizontal line), 1st and 3rd quartiles (box ends), lower and upper limits (whiskers) and outliers (· and *). Area (mm2) Five-a-side Football, Goalball, Judo, Modality, p<0.01

Source: Authors' data



Graph 4. Mean displacement velocity in mm/s of visually impaired athletes who participated in the study according to their sport modality

Note: The graph values represent the median (bold horizontal line), 1st and 3rd quartiles (box ends), lower and upper limits (whiskers) and outliers (·).Velocity (mm/s) Five-a-side Football, Goalball, Judo, Modality, p<0.01

Source: Authors' data

Discussion

The main finding of this study is that athletes with total loss of vision had better semi static bipedal postural balance capacity than athletes with partial loss of vision. Five-a-side football was the sport modality with the lowest oscillation area and displacement velocity. Since the investigated athletes had different degrees of visual impairment and practiced sports with different dynamic characteristics, differences in postural control between the groups would be unexpected.

Considering that the group of five-a-side football players had total loss of vision, it can be supposed that better postural control in relation to the other sport modalities investigated is associated with the development of strategies to compensate for the lack of visual information[23], since these individuals frequently experience challenging sport situations daily. During training sessions and competitions, for example, the athletes need to develop abilities that require dynamic balance control, such as dribbling, carrying the ball and kicking[24], as well as good spatial orientation for their positioning on the court and also the use of the auditory system to listen for the sound emitted by the rattle inside the ball, the team mates using the word "*voy*" and the caller (guide) standing behind the goal[25].

Studies such as those by Schmid et al.[26] and Soares et al.[27] demonstrate that individuals with congenial and acquired visual impairment present similar postural control, suggesting that compensatory reactions to maintain balance, including from the somatosensory and vestibular systems, seem to exist. Nevertheless, it is important to point out that such adjustments do not offset the lack of vision entirely, since visually impaired individuals commonly have poorer postural control in relation to non-visually impaired individuals[14,28].

The present results corroborate those by Juodzbaliene and Muckus[28] on postural balance as a function of visual impairment. Adolescents aged between 11 and 15 years old with partial loss of vision presented poorer postural control comparatively to blind subjects. These findings are supported by the hypothesis that the visual system plays a forceful role in the integration of the other sensorial inputs in postural control[26]. Since individuals with partial loss of vision receive insufficient or many times low quality visual information, it can be supposed that the other systems, those being, the somatosensory and vestibular systems, provide less efficient compensatory adjustments, leading to a greater postural imbalance in this population when compared to blind subjects[28].

Regarding the other sport modalities investigated here, we observed that goalball athletes oscillated less (although without statistical significance) and presented lower displacement velocity ($p<0.01$) when compared to judoists. We believe that these differences may be related to the requirements of each sport modality. Goalball is played exclusively by visually impaired athletes. Even though it is practiced by both totally and partially visually impaired individuals, the use of blindfolds during the match is mandatory, giving them equal training and competition conditions, that is, without the visual component[29].

Based on this sport requirement, it can be considered that blindfolding goalball athletes with partial loss of vision during training and competitions (median of practice of the sport of the group = 4 years, 4.5 sessions a week), similar to the five-a-side football athlete condition, may somehow contribute to a more efficient adjustment of the other systems when compared to judoists, who do not need to compete and train blindfolded. According to Pascual-Leone and Hamilton[30], even short periods of visual deprivation in sighted individuals, for example, five days, seem to result in the stimulation of the primary visual cortex to respond to tactile and auditory stimuli.

Another important aspect is that besides technical and tactic issues specific to goalball, good performance in the sport depends on the capacity of spatial orientation so that the athletes can be aware of their localization in the play area, that is, attack and defense, and the use of the auditory system to locate the audible ball (with an inside rattle). For such, it is important that the athlete develops sensorial abilities such as tact and hearing simultaneously[31], which, in turn may also contribute to a better postural control.

Now, judo has some of its rules modified for the visually impaired, such as the interruption of the match when both the opponents loose contact and non-penalization when the athlete leaves the fight area[29]. In this case, the senses of spatial orientation and hearing may be less important for judo athletes' performance and, therefore, these senses are given lower priority in training than in goalball. Furthermore, as judoists compete all the time by leaning on their opponents, their support base increased and their upper limbs leaning on their opponent - even when they are about to be thrown off balance in an attempt to win the competition, these sport specificities could naturally reduce the unbalance.

To the best of our knowledge, although postural control has so far been commonly investigated in non-impaired athletes, this is the first attempt to investigate issues related to postural control in visually impaired athletes with different functional classifications who practice different modalities of sports. The analyses and discussions of our findings are intended to contribute to stimulate new studies so that information relative to this subject may become more consistent and the factors that may influence postural control in visually impaired athletes can be better clarified.

The limitations of this study are related to the sample size and its sectional nature, which does not allow inferring on causality between the conditions investigated and the results found. Furthermore, the use of static tests in the evaluation of postural control in athletes who present challenged dynamic postural control requires some care in the transposition of the results, such as in other studies in the literature. For this reason, further investigation should be conducted using evaluation methods that are closer to the sport modality. The presence of a group formed by sedentary individuals would also be interesting to investigate the impact of sport practice on postural control in visually impaired individuals.

Conclusions

The current results demonstrate that athletes with total loss of vision present better postural control than athletes with partial loss of vision, which suggests that compensatory reactions for the maintenance of balance in the absence of the visual component seem to be more efficient than in the presence of insufficient visual information.

Comparison of sport modalities practiced by individuals with total and partial loss of vision showed that goalball athletes oscillate less and present smaller displacement velocity than judoists. These differences may be related to specificities and requirements of each sport modality, such as mandatory blindfolding in goalball, which may lead to differentiated chronic adaptations of the systems related to the maintenance of postural control. On the other hand, five-a-side football players presented better postural control, possibly because the group is made up exclusively of individuals with total loss of vision and the compensatory strategies in place are more efficient in the maintenance of their postural control.

These findings, the result of a first effort to investigate postural control in a group of visually impaired athletes who practice different modalities of sports, are important for understanding the athletes' needs in each sport and allow training to be designed ever more adequately so that objectives can be attained

References

1. World Health Organization. [Internet]. Visual impairment and blindness. [acesso em 18 jul 2016]. Disponível em: http://www.who.int/mediacentre/factsheets/fs282/en/.
2. Gleser JM, Margulies JY, Nyska M, Porat S, Mendelberg H, Wertman E. Physical and psychosocial benefits of modified judo practice for blind, mentally retarded children: a pilot study. Percept Mot Skills 1992;74(3 Pt 1):915-25. Doi: 10.2466/pms.1992.74.3.915.
3. Columna L, Fernández-Vivó M, Lieberman L, Arndt K. Recreational physical activity experiences among Guatemalan families with children with visual impairments. J PhysAct Health 2015;12(8):1119-127. DOI: 10.1123/jpah.2014-0257.
4. Mohanty S, Murty PVR, Pradhan B, Hankey A. Yoga practice increases minimum muscular fitness in children with visual impairment. J Caring Sci 2015;4(4):253-63. Doi: 10.15171/jcs.2015.026.
5. Webborn N, Van de Vliet P. Paralympic medicine. Lancet. 2012;380(9836):65-71. DOI: 10.1016/S0140-6736(12)60831-9.
6. Tweedy SM, Beckman EM, Connick MJ. Paralympic classification: conceptual basis, current methods, and research update. PM R 2014;6(8):11-7. Doi: 10.1016/j.pmrj.2014.04.013.
7. Ravensbergen HJ, Mann DL, Kamper SJ. Expert consensus statementtoguidetheevidence-basedclassificationof Paralympic athleteswith visionimpairment: a Delphi study. Br J Sports Med 2016;50(7):386-91. DOI: 10.1136/bjsports-2015-095434.
8. Hrysomallis C. Balance ability and athletic performance. Sports Med 2011;41(3):221-32. DOI: 10.2165/11538560-000000000-00000.
9. Kiers H, Van Dieën J, Dekkers H, Wittink H, Vanhees L. A systematic review of the relationship between physical activities in sports or daily life and postural sway in upright stance. Sports Med 2013;43(11):1171-189. DOI: 10.1007/s40279-013-0082-5.
10. Çolaka T, Bamaç B, Aydin M, Meriç B, Ozbek A. Physical fitness levels of blind and visually impaired goalball team players. Isokinet Exerc Sci 2004;12:247-52. DOI: 10.2466/pms.108.1.129-136.
11. Aydoğ E, Aydoğ ST, Cakci A, Doral MN. Dynamic postural stability in blind athletes using the biodex stability system. Int J Sports Med 2006;27 (5):415-8. DOI: 10.1055/s-2005-865777.
12. Almansba R, Sterkowicz-Przybycień K, Sterkowicz S, Mahdad D, Boucher JP, Calmet M, Comtois AS. Postural balance control ability of visually impaired and unimpaired judoists. Archives of Budo 2012;8(3):153-8. DOI: 10.12659/AOB.883365.
13. Peterka RJ. Sensorimotor integration in human postural control. J Neurophysiol. 2002;88(3):1097-118. DOI: 10.1152/jn.00605.2001.
14. Lee HK, Scudds RJ. Comparison of balance in older people with and without visual impairment. Age Ageing 2003;32(6):643-49. DOI: 10.1016/S1013-7025(09)70022-3.

15. Rutkowska I, Bednarczuk G, Molik B, Morgulec-Adamowicz N, Marszałek J, Kaźmierska-Kowalewska K, et al. Balance functional assessment in people with visual impairment. J Hum Kinet 2015;48:99-109. DOI: 10.1515/hukin-2015-0096.
16. Hrysomallis C. Relationship between balance ability, training and sports injury risk. Sports Med 2007;37(6):547-56. DOI:10.2165/00007256-200737060-00007.
17. Ferrara MS, Peterson CL. Injuries to athletes with disabilities: identifying injury patterns. Sports Med. 2000;30(2):137-43. DOI: 10.2165/00007256-200030020-00006.
18. Magno e Silva MP, Duarte E, Costa e Silva AA, Silva HGPV, Vital R. Aspectos das lesões esportivas em atletas com deficiência visual. Rev Bras Med Esporte 2011;17(5):319-23. DOI: http://dx.doi.org/10.1590/S1517-86922011000500005.
19. Nolan L, Kerrigan DC. Postural control: toe-standing versus heel-toe standing. Gait Posture 2004;19(1):11-5. DOI: http://dx.doi.org/10.1016/S0966-6362(03)00007-9.
20. Prieto TE, Myklebust JB, Hoffmann RG, Lovett EG, Myklebust BM. Measures of postural steadiness: diferences between healthy Young and elderly adults. IEEE Trans Biomed Eng 1996;43(9):956-66. DOI:10.1109/10.532130.
21. Duarte M, Freitas SMSF. Revisão sobre posturografia baseada em plataforma de força para avaliação do equilíbrio. Rev Bras de Fisiot. 2010;14(3):183-92. DOI: 10.1590/S1413-35552010000300003.
22. Lin D, Seol H, Nussbaum MA, Madigan ML. Reliability of CoP-based postural sway measures and age-related differences. Gait Posture 2008;28(2):337-42. Doi: http://dx.doi.org/10.1016/j.gaitpost.2008.01.005.
23. Maurer C, Mergner T, Bolha B, Hlavacka F. Vestibular, visual, and somatosensory contributions to human control of upright stance. Neurosci Lett 2000;281(2-3):99-102. DOI: http://dx.doi.org/10.1016/S0304-3940(00)00814-4.
24. Mello MT, Winckler C. Esporte Paralímpico. São Paulo: Ed. Atheneu;2012.
25. Souza RP, Campos LFCC, Gorla JI. Futebol de 5: Fundamentos e Diretrizes. São Paulo: Ed. Atheneu; 2014.
26. Schmid M, Nardone A, De Nunzio AM, Schmid M, Schieppati M. Equilibrium during static and dynamic tasks in blind subjects: no evidence of cross-modal plasticity. Brain 2007;130 (8):2097-107. Doi: https://doi.org/10.1093/brain/awm157.
27. Soares AV, Oliveira CSR, Knabben RJ, Domenech SC, Borges Junior NG. Análise do controle postural em deficientes visuais postural control in blind subjects. Einstein 2011;9(4 Pt 1):470-76. DOI: http://dx.doi.org/10.1590/S1679-45082011AO2046.
28. Juodzbaliene V, Muckus K. The influence of the degree of visual impairment on psychomotor reaction and equilibrium maintenance of adolescentes. Medicina (Kaunas) 2006;42(1):49-56.
29. Confederação Brasileira de Desportos de Deficientes Visuais. [Internet]. História do goalball. [Acesso em 16 mar 2016]. Disponível em: http://cbdv.org.br/pagina/goalball.
30. Pascual-Leone A, Hamilton R. The metamodal organization of the brain. Prog Brain Res 2001;134:427-45. DOI: 10.1016/S0079-6123(01)34028-1.
31. Amorim M, Corredeira R, Sampaio E, Bastos T, Botelho M. Goalball: uma modalidade desportiva de competição. Rev Port Cien Desp 2010;10(1):221-29. DOI: 10.5628/rpcd.10.01.221

Acknowledgment: Coordination for the Improvement of Higher Education Personnel (*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* - CAPES) and Foundation for Support of Research in the State of Rio de Janeiro (*Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro* - FAPERJ).

Received on Feb, 21, 2017.
Revised on Sep, 09, 2017.
Accepted on Dec, 12, 2017.

Author address: Patrícia dos Santos Vigário. Praça das Nações, n. 34, 3ºandar, Bonsucesso, Rio de Janeiro, RJ, CEP 21041-020. E-mail: patriciavigario@yahoo.com.br