ANALYSIS OF THE BALANCE CONTROL IN SURFERS DURING THE ERECT POSTURE

LOCOMOTOR APPARATUS IN EXERCISE AND SPORTS

ORIGINAL ARTICLE

Cristina Porto Alves Alcantara[1]
Janina Manzieri Prado[1,2]
Marcos Duarte[3]

1. Physical Education and Sports School of the University of São Paulo – São Paulo, Brazil.
2. Physiotherapy School, Mackenzie Presbitarian University – São Paulo, Brazil.
3. Federal University of the ABC – São Paulo, Brazil.

Mailing address:
Rua Santa Adélia, 166 Sala 608-1, Bloco A
09210-170 – Santo André, SP, Brasil
E-mail: cristina.alcantara@usp.br

ABSTRACT

Background: Surfing is a sport that has become considerably popular, which increased interest in research about the aspects that can influence on the performance of these athletes, such as injuries, aerobic fitness and reaction time. Due to the ever-changing environment and high instability required for surfing, the surfers must develop some neuromuscular skills (agility, balance, muscle strength and flexibility) to acquire better performance in this modality. Nevertheless, there are still few scientific studies concerned about the investigation of these motor skills in surfing. Objective: The aim of this study was to evaluate the balance control in surfers compared to practitioners of other physical activities. Methods: Participants remained on a force platform while performing tasks involving visual deprivation (eyes open or closed) and somatosensory disturbance (steady surface or use of foam), with covariation of experimental conditions. The following variables were analyzed: speed and root mean square (RMS) displacement of the center of pressure in the anteroposterior (AP) and mediolateral (ML) directions. Results: The results showed no difference between groups during the experimental conditions, that is to say, both surfers and the control group varied over the conditions of eyes closed and on foam. Conclusion: Although surfing requires the surfer to have great balance control, the results did not reveal a relationship between this sport and better performance in balance control. However, we must consider the small sample size and the fact that this sport requires dynamic balance, while the study evaluated static balance.

Keywords: posture balance, motor skills and sports

INTRODUCTION

Surfing is a modality which has become very popular both in recreational and professional levels [1], which contributes to the increase of research interested in aspects which influence performance of these athletes, such as, aerobic aptitude. It was observed that in high level surfers, aerobic aptitude is better than in lower competitive level surfers, as is observed in other sports modalities of predominantly aerobic characteristic[2].

However, in order to have better performance in surfing, due to an environment in constant change and of high instability characteristic of this modality, it is also important that the surfer develops certain types of neuromuscular abilities, such as: agility, balance control, muscular strength, flexibility and reaction time. However, there are still few studies which evaluate these capacities in surfing, being the majority of the research in this modality limited in describing the types of injuries and their incidence[3-7].

Mendez-Villanueva and Bishop[1] state that fast movement in response to an external stimulus is an important determinant for the surfer's abilities, and significant correlation has been found between competitive level of the surfer and his time of reaction. This fact probably occurs due to the environment and context of the task found in surfing; hence, it is expected that as surfing practice increases, balance improves. This factor, added to time of reaction and physical fitness, could contribute to the competitive success of these athletes. However, there are only few studies which demonstrate this correlation.

Balance may be defined as the ability to keep the gravity center on its support base with minimum oscillation and maximum stability. The capacity to control balance in standing posture is based on the complex interaction between the somatosensory, vestibular and visual functions, besides coordination of movements so that the individual keeps balance[8]. Balance control is highly affected by the nature of the task, by the environmental conditions and by the sensory information available[9-12].

Thus, the ability to keep balance (posture control) is very important for the concept of movement coordination and consequently, crucial in sports activities[13]. Therefore, it is considered an important aspect for good performance and decrease of risk of injuries in sports[14].

Training and experience in sports modalities seem to improve balance required by sports, especially when they involve activities which require greater posture disturbance[15].

Each sport develops specific posture adaptations, that is to say, sports training promotes the abilities to use different sensory information according to the type of sports modality; therefore, the posture alteration are different according to the practiced modality. For instance, in judo the somatosensory information is more important, while in dance the most important are visual[16].

Similarly to what happens in other studied modalities, the understanding of a possible correlation between surfing practice and improvement in posture control may be important to better understand the modality and its real needs, reaching for better competitive

performance and understanding of possible mechanisms which cause injury in the modality.

Thus, the aim of this study is to evaluate balance in surfing practitioners and compare it with balance of individuals who practice other kinds of physical activity.

METHODS

The experimental protocol did not include any invasive procedure or which could represent risk to health of the volunteers. All procedures were approved by the Ethics in Research Committee of the institution in which the experiments were performed. The researchers explained all the procedures involved in the experiment to the volunteers and had they agreed on participating in the study, they signed the consent form before the data collection.

Participants

22 subjects divided in two groups participated in the study. The experimental group consisted of 11 recreational surfing practitioners (nine men and two women). The inclusion criteria for the experimental group were: to have practiced surfing for at least three years; not to have any previous experience in standing fights or dancing modalities. The control group was composed of 11 physically active physical education students (nine men and two women). The inclusion criteria for the control group were: to have practiced regular physical activity for at least the years; not to have previous experience in surfing, standing fights or dancing modalities.

The exclusion criteria for both groups were: previous injuries of lower limbs for at least three months and presence of pathologies which could compromise balance. Age should be between 21 and 35 years[17].

Instruments

Posture oscillations were recorded through a force platform (OR6-1000/AMTI, Watertown, Mass, USA), from which we obtained the center of pressure (CP). The CP dislocations were recorded in the anteroposterior (AP) and mediolateral (ML) directions. The sampling frequency was 200Hz

Tasks

The tasks ranged according to the visual condition and kind of surface: 1) on the floor and with eyes open (FEO); 2) floor and eyes closed (FEC); 3) on foam and eyes open (FEO); and 4) on foam and eyes closed (FEC). At conditions with somatosensory disturbance, the subjects remained on viscoelastic foam (Airex®), placed on the strength platform.

During the tasks the subject should remain on the platform, with arms in front of the body and with distance of approximately 10 cm between feet and as steady as possible. The feet position was marked on the platform and on the foam so that the same position of the participant could be guaranteed during the attempts.

At the conditions with eyes closed, the individuals were simply asked to close their eyes, while at the conditions with eyes open, the subjects should look at a mark three meters away from each participant, which was adjusted according to the participant's height.

Three attempts were performed for each task, with duration of 60 seconds each condition. At every four conditions, a rest period of one minute was given to avoid fatigue.

Data processing

The first and last five seconds of the center of pressure data were removed and a fourth-order lowpass Butterworth filter with cutoff frequency of 10Hz was applied. Root mean square (RMS) of the CP dislocation and the mean velocity (VEL) of the CP in the anteroposterior and mediolateral directions of the three attempts were calculated in each experimental condition. The CP velocity was calculated by the total trajectory of the CP divided by the period (60 seconds).

ANALYSIS

Normality and homogeneity of the variances were verified through the Kolmogorov-Smirnov and Lilliefors tests, respectively. *t* test for independent measures was applied to compare differences between groups for the mass, stature, BMI and age variables. Experimental conditions applied three-factor analysis of variance (ANOVA) (group, vision and surface), two levels in each factor, where the two last factors were considered repeated measurements; the following dependent variables were analyzed: RMS and CP velocity in the AP and ML directions. The Sidak *post hoc* test was performed for multiple comparisons. Mean and standard deviation values were calculated for all variables. The significance level adopted in the statistical tests was 5% and the analyses were performed in the SPSS 14.0.

RESULTS

All participants were able to perform the tasks. The t test did not reveal difference between groups concerning weight (mass), stature (height), BMI and age.

Figure 1 presents means and standard errors of the mean velocity and of the RMS of the CP displacement in the anteroposterior and mediolateral directions, during all the experimental conditions. Analysis of variance (ANOVA) revealed main effect of vision for mean velocity of CP in the anteroposterior ($F(1,20) = 65.9$, $p < 0.001$) and mediolateral ($F(1,20) = 143.1$, $p < 0.001$) directions; for the RMS in the anteroposterior ($F(1,20) = 35.7$, $p < 0.001$) and mediolateral ($F(1,20) = 95.7$, $p < 0.001$) directions. Both the group of surfers and the control group oscillated more during the eyes closed condition.

Analysis of variance (ANOVA) revealed main effect of the type of surface on mean velocity of CP in the anteroposterior ($F(1,20) = 94.84$, $p < 0.001$) and mediolateral ($F(1,20) = 135.9$, $p < 0.001$) directions; for the RMS in the anteroposterior ($F(1,20) = 239.15$, $p < 0.001$) and mediolateral ($F(1,20) = 302.7$, $p < 0.001$) directions. Both groups presented higher posture oscillation during disturbance of the somatosensory system through the use of foam.

DISCUSSION

The results found in the study demonstrate that although the individuals who practice surfing perform tasks which require balance and change of direction in unstable environment, they did not present better balance control compared with the control group, regardless of the type of surface or visual condition. Contrary to what has been hypothesized by Mendez-Villanueva and Bishop[1], that surfing practitioners due to exposure to high instability and environment with constant alterations, tend to have their ability of balance maintenance better compared with other individuals who are not prone to these circumstances.

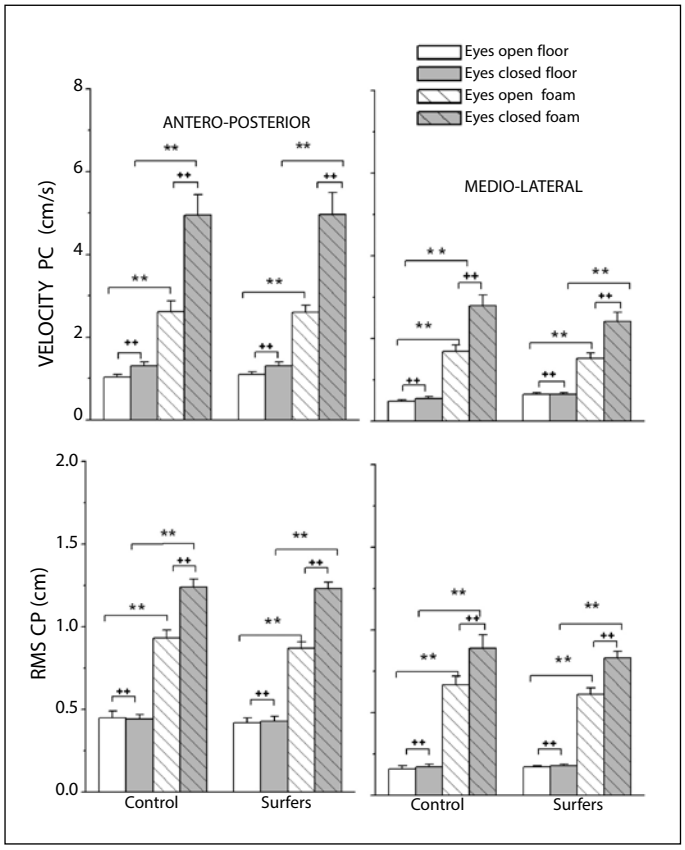

Figure 1. Charts of the means and standard errors of the mean velocity of the center of pressure (CP) in cm/s and the RMS of the PC dislocation in cm in the anteroposterior and mediolateral directions, during all the experimental conditions of the control and experimental groups (surfers).

** surface effect ($p < 0.001$)
++ eyesight effect ($p < 0.001$)

The fact there are no differences between the two studied groups may be explained by the probable learning process of every sports modality, which favors balance control. Moreover, the results may have been influenced by the reduced sample size.

Difference between balance control dependent on the direction analyzed (anteroposterior and mediolateral) has not been observed in the study either. This difference is described by Perrin et al.[16] in dancers, who present more unstable lateral oscillation than judo fighters and another group of individuals non-practitioners of regular physical activity. In addition to that, Paillard[18] also describes that the competitive level of the judo fighters influences on the strategy and anteroposterior balance performance more than lateral balance, since judo requires more anteroposterior posture control than lateral (judo athletes tend to fall more often to the front of back than to the sides).

In the situations with eyes closed both tended to present worse performance when compared with the situations with eyes open of the same group and with the same type of surface, corroborating hence the influence of the visual system in the posture control. Further studies also reported increase of oscillation in conditions with eyes closed[13]; however, there are also authors who did not observe the effect of eyesight in the posture oscillation[19,20].

Apparently, it shows that surfing does not develop posture control abilities more related to the visual system than to the other two sensory systems involved in the posture control (the vestibular and the somatosensory systems).

Differently from what was found by Perrin et al.[16] in classical ballet dancers, who performed better balance control when compared with sedentary individuals, only in the situations with eyes open, while in situations with eyes closed there were not significant differences, which led the authors into classifying the dancers as visually-dependent.

In judo, some authors found better posture control both in situations with and without sensory deprivation (eyes closed) and in conditions with or without external disturbance (movement of the support base), characterizing the judo athletes as less visually-dependent and more somatosensory dependent[16]. Nagy et al.[21] also found lower dependence to eyesight in the *ironman* athletes compared with individuals who performed other type of regular physical activity.

Nevertheless, Paillard et al.[22] showed that more experienced judo fighters are more dependent to eyesight than less experienced ones. Noé and Paillard[23] did not observe a correlation between eyesight and the level of the athletes in skiers. All these variations found between the different modalities and tested conditions corroborate the statement by Duarte[10] and Prado et al.[12], 2007, that posture balance control is highly affected by the nature of the task, by the environmental conditions and by the sensory information available in relation to these two previous factors and the personal conditions. The individual can also present higher or lower level of dependence to the visual information for posture control.

Since all the surfers were amateur, and there was no difference in their performance level, it was not possible to observe a correlation between the ability of posture control and the performance level in surfing among these individuals, a correlation already described in other modalities such as ski[23], shooting[24], soccer[25] and judo[17,22].

These results suggest that surfing possibly offers previous experience input to the athlete, which enables better performance in the tasks which involve balance, such as in *tai chi chuan* already described by many authors[26-32].

According to Yoshitomi[15], sensory-motor performance may be stimulus-dependent; therefore, training in the modality may improve balance or vice-versa. This is a justification for sensory-motor training for surfing practitioners who wish to improve their performance during this modality, as shown in the study by Kovacs et al.[33], in which figure skaters performed neuromuscular training, significantly improving their posture control, which could have also influenced on their performance during figure skating.

CONCLUSION

Balance control is influenced by the type of sensory disturbance. However, no difference has been observed between posture control of surfing practitioners when compared with practitioners of other types of physical activity. However, we suggest increase in the sample as well as better selection of the surfers, with longer frequency time and practice. Additionally, the study evaluated static balance; it would be interesting for further research to evaluate surfers at dynamic conditions or with manipulation of the support bases, since the sport is a modality which requires dynamic balance.

All authors have declared there is not any potential conflict of interests concerning this article.

REFERENCES

1. Mendez-Villanueva A, Bishop D. Physiological Aspects of Surfboard Riding Performance. Sports Med 2005;35:55-70.
2. Mendez-Villanueva A, Perez-Landaluce J, Bishop D, Fernandez-Garcia B, Ortolano R, Leibar X, et al. Upper body aerobic fitness comparison between two groups of competitive surfboard riders. J Sci Med Sport 2005;8:43-51.
3. Lowdon BJ, Pitman AJ, Paeman NA, Ross K. Injuries to international competitive surfboard riders. J Sports Med Phys Fitness 1987;27:57-63.
4. Nathanson A, Haynes P, Galanis D. Surfing Injuries. Am J Emerg Med 2002;20:155-60.
5. Taylor D, Bennett D, Carter M, Garewal D, Finch CF. Acute injury and chronic disability resulting from surfboard riding. J Sci Med Sport 2004;7:429-37.
6. Zoltan TB, Taylor K. Health Issues for Surfers. Am Fam Physician 2005;71:2313-7.
7. Nathanson A, Bird S, Dao L, Tam-Sing K. Competitive Surfing Injuries: A Prospective Study of Surfing-Related Injuries Among Contest Surfers. Am J Sports Med 2007;35:113-7.
8. Emery CA. Is there a clinical standing balance measurement appropriate for use in sports medicine? A review of the literature. J Sci Med Sport 2003;6:492-504.
9. Duarte M. Análise estabilográfica da postura ereta humana quasi-estática (Tese de Livre Docência). São Paulo (SP): EEFEUSP; 2000.
10. Duarte M, Harvey W, Zatsiorsky M. Stabilographic analysis of unconstraines standing. Ergonomics 2000;43:1824-39.
11. Prado JM, Stoffregen TA, Duarte M. Postural sway during dual tasks in young and elderly adults. Gerontology 2007;53:274-81.
12. Freitas SM, Prado JM, Duarte M. The use of a safety harness does not affect body sway during quiet standing. Clin Biomech 2005;20:336-9.
13. Hahn T, Foldspang A, Vestergaard E, Ingemann-Hansen T. One-leg standing balance and sports activity. Scand J Med Sci Sports 1999;9:15-8.
14. Hrysomallis C, McLaughlin P, Goodman C. Relationship between static and dynamic balance tests among elite Australian Footballers. J Sci Med Sport 2006;9:288-91.
15. Yoshitomi SK, Tanaka C, Duarte M, Lima F, Morya E, Hazime F. Respostas posturais à perturbação externa inesperada em judocas de diferentes níveis de habilidade. Rev Bras Med Esporte 2006;12:159-63.
16. Perrin P, Deviterne D, Hugel F, Perrot C. Judo, beter than dance, develops sensorimotor adaptabilities involved in balance control. Gait Posture 2002;15:187-94. 18. 17. Kollegger H, Baumgartner C, Wöber C, Deecke L. Spontaneous Body Sway as a Function of Sex, Age, and Vision: Posturographic Study in 30 Healthy Adults. Eur Neurol 1992;32:253-9.
17. Paillard T. Influence of postural regulation in male judokas' direction of falls. Perceptual and Motor Skills 2005:101:885-90.
18. Marsh AP, Geel SE. The effect of age on the attentional demands of postural control. Gait Posture 2000;12:105-13.
19. Shumway-Cook A, Woollacott M. Attentional demands and postural control: the effect of sensory context. J Gerontol A Biol Sci Med Sci 2000;55:M10-6.
20. Nagy E, Toth K, Janositz G, Kovacs G, Feher-Kiss A, Angyan L, et al. Postural control in athletes participating in an ironman triathlon. Eur J Appl Physiol 2004;92:407-13.
21. Paillard T, Costes-Salon C, Lafont C, Dupui P. Are There differences in postural regulation according to the level of competition in judoists? Br J Sports Med 2002;36:304-5.
22. Noé F, Paillard T. Is postural control affected by expertise in alpine skiing? Br J Sports Med 2007;39:835-7.
23. Era P, Konttinen N, Mehto P, Saarela P, Lyytinen H. Postural Stability and Skilled Performance – A Study on Top-level and Naïve Rifle Shooters. J Biomech 1996;29:301-6.
24. Paillard T, Noé F, Rivière T, Marion V, Montoya R, Dupui P. Postural Performance and Strategy in the Unipedal Stance of Soccer Players at Different Levels of Competition. J Athl Train 2006:41:172-6.
25. Hass CJ, Gregor RJ, Waddell DE, Oliver A, Smith DW, Fleming RP, et al. The influence of Tai Chi Training on the Center of Pressure Trajectory During Gait Initiation in Older Adults. Arch Phys Med Rehabil 2004;85:1593-8.
26. Mak MK, Ling P. Mediolateral Sway in Single-Leg Stance Is the Best Discriminator of Balance Performance for Tai-Chi Practioners. Arch Phys Med Rehabil 2003;84:683-6.
27. Wong AM, Lin Y, Chou S, Tang F. Coordination Exercise and Postural Stability in Elderly People: Effect of Tai Chi Chuan. Arch Phys Med Rehabil 2001;82:608-12.
28. Harmer PA, Li F. Tai Chi and falls prevention in older people. Med Sport Sci 2008;52:124-34.
29. Wong AM, Lan C. Tai Chi and balance control. Med Sport Sci 2008;52:115-23.
30. Li F, Harmer P, Mack KA, Sleet D, Fisher KJ, Kohn MA, et al. Tai Chi: moving for better balance – development of a community-based falls prevention program. J Phys Act Health 2008;5:445-55.
31. Li F, Harmer P, Glasgow R, Mack KA, Sleet D, Fisher KJ, et al. Translation of an effective tai chi intervention into a community-based falls-prevention program. Am J Public Health 2008;98:1195-8.
32. Kovacs E, Birmingham T, Forwell L, Litchfield R. Effect of Training on Postural Control in Figure Skaters. A Randomized Controlled Trial of Neuromuscular Versus Basic Off-Ice Training Programs. Clin J Sport Med 2004;14:215-24.