ORIGINAL RESEARCH

Analysis of velocity and direction of trunk movement in wheelchair basketball athletes

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OBJECTIVE: Postural control of the trunk is important to stabilize the entire body and to generate muscle force during sports activities. When the trunk is stable, it is easier and safer to transfer applied forces along the body to perform any motor task because it enhances muscle action and reduces joint loads. Postural control of the trunk is important to stabilize the entire body and to generate muscle force during sports activities. The aim of this study is to verify the velocity and direction of trunk movement in wheelchair basketball athletes.

METHOD: Participants were 26 wheelchair basketball athletes, they were tested on the NeuroCom Balance Master System, protocol: Rhythmic Weight Shift. They were asked to sway the entire body to the right, left, forward and backward. Trials evaluated these movements in low, medium and high velocities.

RESULT: Movement velocity was very significantly affected by task speed and task direction. The highest movement velocity was observed for the fast task and for the left/right direction. There was no interaction between the task and its direction.

CONCLUSION: Wheelchair basketball athletes moved their body faster in the left/right direction. This result suggests that postural control is direction-dependent for the wheelchair-bound individual.

KEYWORDS: basketball; biomechanics; athletes.

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INTRODUCTION

The human spine is an unstable complex mechanical structure.[1] After a spinal cord injury (SCI), the normal signaling between the brain and the muscles distal to the injury is partly or completely disrupted. Bjerkefors et al.[2] and Myers et al.[3] suggested that most people with a SCI have very low physical capacity. Low physical capacity is a consequence of paralysis of the lower limbs, leading to a wheelchair-dependent life. Maintaining an active lifestyle is difficult with wheelchair dependency; therefore, physical deconditioning is likely to occur.

The rehabilitation of patients after spinal cord injury normally lasts for several years. Rehabilitation may be difficult because the consequent physical impairment reduces motor activity.[4] On the other hand, rehabilitation training improves physical capacity, cardiorespiratory function, and the cardiac and metabolic state in patients after SCI.[5-6]

Postural control of the trunk is important to stabilize the entire body and to generate muscle force during sports activities. When the trunk is stable, it is easier and safer to transfer applied forces along the body to perform any motor task because it enhances muscle action and reduces joint loads.[7]

An approach to the challenge of attaining balance control is to apply perturbations to the body and to record the compensatory responses. For example, the sudden translation of the support base during quiet standing or sitting accelerates the body center of mass and increases the risk of a fall. In order to avoid such a risk, an opposite acceleration is necessary.[2] The compensatory mechanisms for unpredictable perturbations are purely reactive, whereas predictable perturbations allow for anticipatory postural adjustments. Training may possibly affect these two mechanisms differently. In addition, the new test situation becomes more realistic in terms of simulating everyday scenarios.[2]

Different possibilities of physical activity and sport for disabled individuals include the practice of wheelchair basketball, which has been investigated through a number of different scientific studies, including the assessment of physiological aspects,[8,9-10] nutritional factors,[11] kinematic features[12-13]and injuries.[14,15]

When considering how athletes use wheelchairs for movement during a game, the function of the trunk has become one of the main parameters for the verification of functional capacity, including one of the main factors used in the class evaluation of the athlete.[8,16]

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In wheelchair basketball, the functional classification system is based mainly on the competence of the classifier in recognizing an athlete's physical ability to execute fundamental movements through field-testing and game observation. These movements include trunk stability, sitting balance and trunk movement in the horizontal, frontal and sagittal planes, such as pushing and handling the wheelchair, dribbling, passing, shooting and rebounding the ball.[8]

In the matter of postural balance, the literature contains studies conducted on a balance board in order to measure seated postural stability in individuals with disabilities;[6,13-17] this is because individuals with SCI use different postural strategies to control sitting balance during the execution of task.[6,18] For wheelchair athletes, trunk balance is crucial for movement and the performance analysis of the trunk with respect to postural balance is a basic parameter for functional evaluation.[19]

If we consider that the disabled individual has significant changes in orthopedic functionality because of a reduction of balance due to loss of proprioceptive and neuromuscular sensory feedback from trauma-based SCI,[20,21] then the measuring of components that are part of the functionality of practicing basketball surely contribute to the advancement of sport and performance for the athlete.

The aim of this study was to verify the velocity and direction of trunk movement in wheelchair basketball athletes.

METHODS

This was an observational cross-sectional study carried out without intervention. The participants were 26 wheelchair basketball athletes. An information sheet containing study goals and content was given to the enrolled participants. All participants gave written informed consent prior to joining the study. The study was approved by the Ethics Committee of the University of São Paulo (n°063/10) and performed at the Laboratory for the Study of Movement, Institute of Orthopedics and Traumatology, Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo.

Procedures

The participants were tested on the NeuroCom Balance Master System. The sampling rate was 100 Hz. The NeuroCom Balance Master System™ has multiple testing protocols designed to examine various balance measures. This study ran the Rhythmic Weight Shift test with the participants sitting in a wheelchair. Participants wore a security belt to avoid accidental falls during testing.

After 10 seconds of practice, participants were ready to start the test. They were asked to sway the entire body to the right, left, forward and backward to move a dot on the computer display in order to follow a moving yellow cue also projected on the display. This cue produced two movements: left/right and forward/backward. The Rhythmic Weight Shift test consisted of six trials, normally conducted in the following order: (1) left/right, slow (3 second transitions); (2) left/right, medium (2 second transitions); (3) left/right, fast (1 second transitions); (4) forward/backward, slow (3 second transitions); (5) forward/backward, medium (2 second transitions) and; (6) forward/backward, fast (1 second transitions).

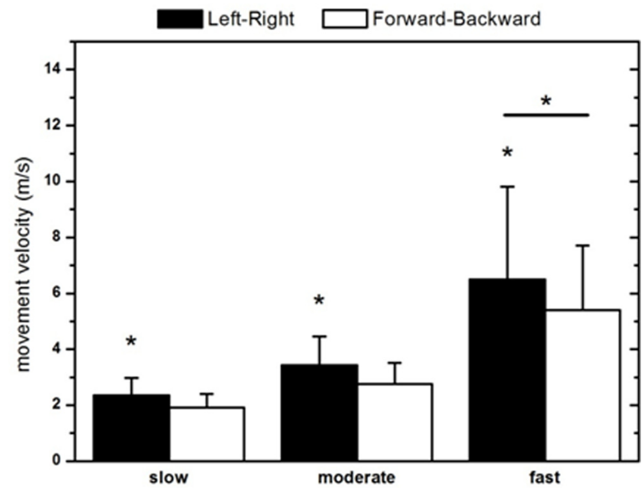

Figure 1 - Movement velocity means and standard deviations across task condition (slow, moderate and fast) and task direction (black: left/right; white: forward/backward). Movement velocity was affected by task condition ($F_{(2,185)} = 79.5$, $p < 0.001$) and task direction ($F_{(1,185)} = 8$, $p = 0.005$). The highest movement velocity was observed for the fast task ($p < 0.05$) and for the left/right direction ($p < 0.05$). There was no interaction between the task and its direction.

Statistical analysis

A two-way analysis of variance (ANOVA) test was applied to verify the effects of each task condition (slow, moderate and fast) and each task direction (left/right and forward/backward directions) on the movement velocity across the participants. The post hoc analysis was performed with Tukey HSD test. The level of significance was set at $p < 0.05$.

RESULTS

A two-way ANOVA was used to show the effects of condition (slow, moderate and fast) and task direction (left/right and forward/backward) factors to movement velocity as shown in Figure 1. Movement velocity was affected by task condition ($F_{(2,185)} = 79.5$, $p < 0.001$) and task direction ($F_{(1,185)} = 8$, $p = 0.005$). The highest movement velocity was observed for the fast task ($p < 0.05$) and for the left/right direction ($p < 0.05$). There was no interaction between the task and its direction.

DISCUSSION

The most relevant finding in this study was that wheelchair basketball athletes moved their body faster through the left/right direction. This result suggests that postural control is direction-dependent for the wheelchair-bound individual. To perform daily and sport activities, these individuals need to improve their physical fitness by principally acquiring muscle force to move the wheelchair. Indeed, such a physical activity may also improve the medio-lateral postural control of the trunk.

Postural control of the trunk is necessary to balance the body against the gravity field, to perform the whole-body voluntary movements and to assist the upper limbs to move functionally. Trunk postural control might be impaired for different neuropathological conditions and its recovery predicts functional outcome.[16]

However, trunk function under pathological conditions sometimes fails. For SCI, for example, rehabilitation is necessary to recover trunk control.[22] Sport activities enhance the rehabilitation of SCI individuals because they have to achieve a higher level of precision and accuracy during motor tasks to deal with symmetrical and asymmetrical motor conditions, and to organize new synergistic muscle patterns to generate the strength and resistance required for and during a basketball game.[4]

Another reported effect of basketball training was the ability to improve movement speed throughout the task. During training, wheelchair basketball athletes are traained and accustomed to attempting several ball shots in a short-term time sequence. Such movements can be performed in two ways: by arm movement only, or by trunk and arm movement. Performing the movement not only by stretching the arms forward but also by moving forward the trunk causes a greater shift in Center of Pressure displacement.[22]

One of the main results of our study showed that the faster the task, the faster the wheelchair basketball athlete moved their trunk. Possibly, the wheelchair athletes were able to increase their movement velocity as the task became faster in order to perform the task correctly. After thoracic SCI, the normal signaling between the brain and lower limb muscles is disrupted. During rehabilitation, individuals with SCI have to re-learn to move and balance the upper body in a sitting position.[2]

The second main result was that the wheelchair basketball athletes moved faster through the left/right than through the anterior-posterior direction. A common experimental technique to challenge balance control is to deliver various types of perturbations and record compensatory responses (i.e., sudden translations of the support-surface). Mechanically, such translations consist of a positive acceleration, followed by a negative acceleration (deceleration).[2] However, in this study we decided to provide a perturbation by changing the speed with functional stimuli that favor the displacement of the center of gravity in anterior-posterior (AP) and in latero-lateral movement of the trunk.

For AP movements, the trunk extensor muscles are typically stronger than the flexors; hence, backward forces tend to be greater than forward forces.[16] Thus, for existing functionality, it is probably necessary to aid the support of the lower limbs in AP movements when compared to medio-lateral movements.

Without fixation, the forces developed at the top of the trunk have to be balanced at joints lower down, such as for example, between the trunk and the pelvis, in order for the force to be transmitted to the seat surface. Even if the pelvis and lower spine can be actively stabilized in an adequate manner, there could be further stabilization problems if the trunk horizontal forces were to overcome the limiting frictional force between the buttocks and the seat.[16] This could occur if the coefficient of friction between the clothing and the seat materials were not high enough or if the buttocks were to partially rise off the seat, for example, through inappropriate pelvis stabilization or leg action. Then the leg muscles would have to be used to stabilise the leg joints and transmit part or all of the reaction force to the floor. If the leg muscles can be adequately activated to resist these forces, the limiting factor would then be the frictional force between the feet and the floor. Thus, the motor control problem is greater and potentially involves the coordination of many parts of the body when the pelvis is free to move.[16]

CONCLUSION

Wheelchair basketball athletes moved their body faster in the left/right direction. This result suggests that postural control is direction-dependent for the wheelchair-bound individual.

RESUMO

OBJETIVO: O controle postural do tronco é importante para estabilizar o corpo e gerar força muscular durante atividades esportivas. Quando o tronco está estabilizado, é mais fácil e mais seguro transferir forças aplicadas ao longo do corpo para executar qualquer tarefa motora, porque incrementa-se a ação muscular e reduzem-se as cargas articulares. O controle postural do tronco é importante para estabilizar o corpo inteiro e gerar força muscular durante atividades esportivas. O objetivo deste estudo é verificar a velocidade e direção do movimento do tronco em atletas de basquetebol em cadeira de rodas.

MÉTODO: Participaram 26 atletas de basquetebol em cadeira de rodas testados no sistema ''NeuroCom Balance Master'', através do protocolo ''Mudança Rítmica de Carga''. Foram convidados a lançar todo o corpo para a direita, esquerda, para frente e para trás. Testes avaliaram esses movimentos em baixa, média e alta velocidade.

RESULTADO: A velocidade de movimento foi significativamente afetada pela velocidade e direção da tarefa. A maior velocidade de movimento foi observada para a tarefa rápida na direção esquerda/direita. Não houve interação entre a tarefa e sua direção.

CONCLUSÃO: Atletas de basquetebol em cadeira de rodas moveram-se mais rapidamente na direção esquerda/direita. Este resultado sugere que o controle postural para o indivíduo em cadeira de rodas é dependente da direção do movimento.

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