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ORIGINAL ARTICLE

Thoracoabdominal mobility is improved in subjects with tetraplegia after one year of wheelchair rugby training

La mobilité thoracique est améliorée chez les sujets tétraplégiques après un an d'entraînement de rugby en fauteuil roulant

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Thoracic wall;
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Summary
Objective. — The purpose of this study was to analyse the effect of one year of wheelchair rugby training on thoracoabdominal mobility and its association with lung volume in adults with tetraplegia.
Equipment and methods. — Participants (10 male adults with chronic spinal cord injury at cervical level) underwent to regular training in wheelchair rugby. At the beginning and after one year of training, lung volume and tridimensional mobility of four-chest wall compartments (superior and inferior thorax, superior and inferior abdomen) were obtained by spirometric testing and kinematic analysis, respectively.
Results. — Seven athletes completed the study. During quiet breathing, significant improvements and linear relationships were observed for the tidal volume (16.9%), superior thorax (61.3%) and inferior thorax mobility (83.7%). During maximal breathing, significant improvements were found for the vital capacity (24.8%) and superior thorax mobility (31.5%). Besides that, there was also a significant linear relationship between the vital capacity volumes and mobility in the

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superior and inferior thorax and superior abdomen. These findings could support the practice of wheelchair rugby to reduce respiratory dysfunction in tetraplegics.

MOTS CLÉS
Paroi thoracique ;
Cinématique ;
Spirométrie ;
Lésion de la moelle épinière ;
Paralympique

Résumé
Objectifs. — Le but de cette étude était d'analyser l'effet d'une année d'entraînement de rugby-fauteuil sur la mobilité thoraco-abdominale et son association avec le volume pulmonaire chez les adultes tétraplégiques.
Matériels et méthodes. — Les participants (10 hommes adultes souffrant de lésions de la moelle épinière au niveau cervical) ont subi un entraînement régulier de rugby-fauteuil. Avant et après une année d'entraînement, le volume pulmonaire et de la mobilité tridimensionnelle de quatre compartiments de la paroi thoracique (thorax supérieur et inférieur, l'abdomen supérieur et inférieur) ont été obtenus par spirométrie et analyse cinématique, respectivement.
Résultats. — Sept athlètes ont terminé l'étude. Pendant la respiration de repos, des améliorations significatives ont été observées pour le volume courant (16,9 %), et la mobilité du thorax supérieur (61,3 %) et thorax inférieur (83,7 %), et il y avait une relation linéaire significative entre ces variables. Pendant la respiration maximale, des améliorations significatives ont été trouvées pour la capacité vitale (24,8 %) et la mobilité du thorax supérieure (31,5 %), et il y avait une relation linéaire significative entre la capacité vitale et la mobilité du thorax supérieur et inférieur et de l'abdomen supérieur. Ces résultats pourraient soutenir que la pratique du rugby-fauteuil a un effet réducteur de la dysfonction respiratoire chez les tétraplégiques.

1. Introduction

Wheelchair rugby (WR) is a paralympic team sport that was designed for athletes with a combination of impaired or absent upper and lower limb movement. Influenced by both the anaerobic and aerobic capacity [1,2], a WR game is divided into four periods of 8 minutes each; when adding in the time in which the clock is stopped when a goal is scored, a foul or violation is committed, or a player falls, the game may be longer than an hour. During a match, between frequent accelerations and decelerations, high-level players cover between 3.501 and 5.657 m, depending on their functional classification score [3]. These numbers show that WR is an intense physical activity for disabled persons, raising the hypothesis that WR training could lead to positive improvements in the respiratory system, thereby helping people with spinal cord injuries achieve the recommended levels for the prevention and control of diseases.

The volume and time aspects of breathing depend on the control of the cortical and peripheral mechanisms of the nervous system and the coordinated action of the breathing muscles [4,5]. Alterations in these mechanisms can lead to changes in the thoracoabdominal motion and in the breathing pattern components [6—10]. Chest wall motion is functionally related to ventilation in healthy persons: during inhalation, the inspiratory muscles contract, expanding the chest wall and further increasing its volume. This expansion leads to a decrease in the air pressure in the alveoli to below atmospheric pressure, which makes the air rush in through the lungs. Therefore, normal thoracoabdominal motion is necessary to the success of ventilation.

In view of the sensory, motor and autonomic alterations below the level of the lesion, people with spinal cord injury have important impairment in their breathing function. This impairment is characterised by paralysis or weakness of the breathing muscles, affecting both the inspiratory and expiratory muscles based on the level of the spinal cord injury [4,11]. These alterations are generally responsible for the loss in the ability to generate high lung volumes, leading to peripheral microatelectasis and low lung compliance [4,12], which in turn contributes to the increase in morbidity and mortality rates, especially in cervical spinal cord injuries [13]. Furthermore, breathing function impairment keeps improving even after injury becomes chronic [14].

Impairment in the respiratory muscles of tetraplegic persons is reflected by alterations in the rib cage and abdominal motion patterns during breathing. Intercostal muscle paralysis decreases rib cage excursion by poorly transmitting and distributing the inspiratory forces throughout the rib cage, while abdominal motion is affected by the decreased compliance because of the lack of abdominal muscle action [15]. When diaphragm is not affected, like in lower cervical spinal cord injury, the abdominal pressure resulting from its contraction would have an expanding action on the lower rib cage [16]. Nevertheless, the lack of intercostal muscle action leads the diaphragm to exert a constriction action on the upper rib cage, generating a paradoxical inspiratory movement [17].

The physical efforts in the daily activities of wheelchair users are not sufficient for improving breathing function [18]. To overcome impairments in the respiratory system due to spinal cord injury, these individuals have been encouraged to participate in exercise programs, group activities and sports, which are aimed at preventing disease, maintaining functional independence and improving respiratory capacity [19,20].

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