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ORIGINAL RESEARCH

Respiratory muscle strength and thoracoabdominal mobility in sedentary elderly, adults and players of adapted volleyball: a pilot study

Força muscular respiratória e mobilidade toracoabdominal em idosos e adultos sedentários e praticantes de voleibol adaptado: estudo-piloto

Fuerza muscular respiratoria y la movilidad tóraco-abdominal en ancianos y adultos sedentarios y practicantes de voleibol ajustado: estudio piloto

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ABSTRACT | A number of modifications accompany the aging process, including changes in the respiratory system. However, regular physical activity may be an effective way to prevent these alterations. The purpose of this study was to evaluate and compare the thoracoabdominal mobility and respiratory muscle strength, in sedentary individuals and in those who participate in adapted volleyball. Subjects aged 50 and 80 years old that were participating in adapted volleyball for at least one year, and sedentary ones who neither smoked nor presented pulmonary, cardiovascular or musculoskeletal diseases were evaluated for thoracoabdominal mobility by cirtometry at the axillary (CAx), xiphoid (CX) and abdominal (CAb) levels. They were also assessed for respiratory muscle strength by measuring their maximal respiratory pressures (MIP and MEP). The active group had greater values of cirtometry compared to the sedentary group (56.4% higher in CAx, 83.4% in Cx and 63.5% in CAb) and higher values of MEP (41.3% higher in absolute MEP and 39.5% of MEP in predicted %). The MIP (cmH_2O and predicted %) did not differ between groups. Participation in adapted volleyball may have contributed to maintained thoracicoabdominal mobility and expiratory muscle strength in these elderly and adults.

Keywords | Respiratory Mechanics; Aging, Breath Tests; Physical Therapy Modalities; Volleyball.

RESUMO | Uma série de modificações acompanham o processo de envelhecimento, incluindo mudanças no sistema respiratório. No entanto, atividade física regular pode ser uma maneira eficaz de prevenir estas alterações. O objetivo deste estudo foi avaliar e comparar a mobilidade toracoabdominal e a força muscular respiratória em sedentários e praticantes de voleibol adaptado. Foram incluídos indivíduos entre 50 e 80 anos de idade, que praticam voleibol adaptado há pelo menos um ano, e sedentários não tabagistas e sem doenças pulmonares, cardiovasculares ou musculoesqueléticas. Foram avaliadas a mobilidade toracoabdominal, por meio da cirtometria axilar (CAx), xifoideana (CX) e abdominal (CAb), e a força muscular respiratória por meio das medidas de pressões respiratórias (PI máxima e PE máxima). O grupo ativo apresentou valores de cirtometria maiores em relação ao sedentário (56,4% maior na CAx, 83,4% na CX e 63,5% na CAb), bem como maiores valores da PE máxima (41,3% maior na PE máxima absoluta e 39,5% da PE máxima em % predita). A PI máxima (cmH_2O e % predita) não mostrou diferença entre os grupos. Concluiu-se que a prática de voleibol adaptado pode ter contribuído para a manutenção da mobilidade toracoabdominal e força muscular expiratória nestes idosos e adultos.

Descritores | Mecânica Respiratória; Envelhecimento, Testes Respiratórios; Modalidades de Fisioterapia; Voleibol.

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RESUMEN | Una serie de cambios acompañan el proceso de envejecimiento, incluso alteraciones en el sistema respiratorio. Sin embargo, la actividad física regular puede ser un modo eficaz de prevenir esas alteraciones. El objetivo de eso estudio fue evaluar y comparar la movilidad tóraco-abdominal y la fuerza muscular respiratoria en sedentarios y practicantes de voleibol ajustado. Fueron inclusos sujetos entre los 50 y 80 años de edad que practican voleibol ajustado por pelo menos un año y sedentarios no tabaquistas y sin enfermedades pulmonares, cardiovasculares o musculoesqueleticas. Se evaluó la movilidad tóraco-abdominal por medio de la cirtometria axilar (CAx), xifoidea (CX) y del abdomen (CAb), y la fuerza muscular respiratoria por medio de las mensuraciones de las presiones respiratorias (PI máxima y PE máxima). El grupo activo presentó valores de cirtometria mayores en relación al sedentario (56,4% mayor en la CAx, 83,4% en la CX y 63,5% en la CAb), así como valores mayores de la PE máxima (41,3% mayor en la PE máxima absoluta y 39,5% de la PE máxima en % predicho). La PI máxima (cmH_2O y % predicho) no mostró diferencia entre los grupos. Se concluyó que la práctica de voleibol ajustado puede tener contribuido para la manutención de la movilidad tóraco-abdominal y la fuerza muscular espiratoria en esos ancianos y adultos.

Palabras clave | Mecánica Respiratoria; Envejecimiento, Pruebas Respiratorias; Modalidades de Fisioterapia; Voleibol.

INTRODUCTION

Aging is a dynamic and progressive process that causes changes in all body systems. Structural alterations of the respiratory system due to aging involve the lungs, rib cage, and respiratory muscles, particularly the diaphragm[1]; whereas functional changes include modifications in lung volume and capacity due to structural alterations[2]. These may be associated with sarcopenia, i.e. loss of muscle mass due to aging[3],which begins at 50 years old and causes losses of 1% per year, increasing to 3% per year after age 60, thus promoting decreased muscle strength[4,5].

This muscle loss may happen because of interaction of metabolic, physiological, and functional disorders, innervation alterations, decreases in hormones, increased inflammatory mediators, and alteration of protein-calorie ingestion that occurs with aging[6,7]. Thus, aging affects the respiratory system[8] and can be seen in reduced spirometric values according to age[9], decreased vital capacity, increased residual volume, and decreased mobility of the thoracic wall[10,11].

Previously studies suggest that diaphragm strength is reduced in the elderly population[12]. Besides, in spite of its continuous contractile activity during the normal life cycle, the diaphragm presents reduced capacity to generate maximal strength during senescence[13].

Nevertheless, considering the effects of aging on the rib cage, there is a decrease in its elasticity, probably caused by the progressive calcification of the involved joints, and also a reduction of intervertebral spaces[14], which could be associated with the progressive loss of thoracic mobility during the aging process.

Physical inactivity is currently the fourth most important cause of mortality worldwide. Regular physical exercise is related to lower rates of mortality, heart diseases, high blood pressure, strokes, type 2 diabetes, and cardiorespiratory and musculoskeletal disorders[15].

It has been reported that preventive physical exercises is the best way to slow sarcopenia due to aging[7,16], besides being related to lower rates of other diseases, like previously mentioned[15].

Thus, physical training, even if not specifically for the respiratory muscles, promotes increased respiratory muscle strength, which indicates that such decline can be slowed or reverted with the regular practice of physical exercises[17].

Due to the systemic alterations that accompany aging, which are aggravated by being sedentary, physical activities and sports are encouraged among this population[15]. Adapted volleyball became popular with elderly and adults because it is an impact sport, therefore it can be a support to osteogenesis and to prevent osteoporosis[18]. Furthermore, it involves major muscle groups, particularly those of the upper limbs, which indirectly influence the respiratory system and can interfere in thoracic mobility and respiratory muscle strength[19].

Therefore, our hypothesis was that regular participation in adapted volleyball would contribute to preserved thoracoabdominal mobility and respiratory muscle strength in elderly and adults.

The objective of the present study was to evaluate a sample of adults over 50 years of age and compare the thoracoabdominal mobility and respiratory muscle strength of sedentary subjects with that of those who play adapted volleyball.

METHODOLOGY

This study was approved by the Research Ethics Committee of the University of Piracicaba (UNIMEP), protocol number 70/10, and all volunteers signed a free informed consent form.

This was a pilot, cross-sectional and case-control study, in which sedentary and active volunteers who participated in adapted volleyball were evaluated regarding their thoracoabdominal mobility and respiratory muscle strength.

Participants

Volunteers were considered sedentary according to the questionnaire of Baecke et al.[20] and were selected from the community, and the active volunteers were recruited from a municipal recreation center. The study included subjects between 51 and 80 years old who were non-smokers, had no diagnosed pulmonary, cardiovascular or musculoskeletal diseases, did not use medications that could interfere with the variables studied and, for the active group, who had been in the training program for at least one year.

Materials and procedure

The active group (AG) activities were carried out twice a week for 90 minutes as follows: an initial stretching period of the muscle groups followed by a warm-up consisting of light running and ball throwing; a training session consisting of net and backcourt tactics; a variety of physical development exercises (abdominals, throwing, technical and tactical training) and, finally, practice matches. A physical educator monitored and scheduled all activities. While standing and shirtless, the volunteers' thorax and abdomen circumferences were measured using cirtometry, following that described by Jamami et al.[21].

This method consisted of measuring the trunk circumference with a measuring tape scaled in centimeters at the axillary (CAx), xiphoid (CX), and abdominal (CAb) levels. For the CAx and CX levels, the reference points were the anterior axillary line and the xiphoid process, respectively, and for the abdominal level, it was the umbilicus. The standardized measurement procedure consisted of keeping the zero point of the measuring tape on the midline of the body and horizontally aligned with the respective level, with the other end of the tape loosen to allow its dislocation. The tape was positioned in a way to maintain the soft tissue contours unaltered.

After the subjects were trained, they were instructed to perform maximal inspiration and expiration for each thoracic level evaluated. The measurements were taken at the end of the maximal expiration. The participants held the maximal inspiration and expiration for at least two seconds in order to allow data collection. All measurements were taken three times at each level. The differences between the inspiratory and expiratory ones were calculated, and the mean of the three measurements of each level was used for analysis.

In order to evaluate the maximal respiratory pressure, the equations proposed[22] were used to predict the normal values of maximal inspiratory (MIP) and maximal expiratory (MEP) pressures. The respiratory pressures were measured using an analog manovacuometer (GER-AR®, São Paulo, Brazil) with an operational interval of ±300 cmH_2O. Readings of the equipment had been previously checked against a mercury column.

All measurements were collected by the same researcher and carried out using the same verbal commands, with the volunteers seated and having their nostrils occluded with a nasal clip to avoid air leak. The MIP was measured during effort, beginning with the residual volume (RV), whereas the MEP was achieved according to total lung capacity (TLC). Each volunteer performed five technically satisfactory maximal inspiration and expiration efforts, i.e. without perioral air leakage, held for at least one second and of similar values (≤10%), in which the measurement with the highest value was considered in the analysis[22].

Statistical analysis

Data were analyzed in the software Statistical Package for the Social Sciences (SPSS), version 13.0. The continuous variables were expressed by central tendency and dispersion, and the categorical ones by frequencies. Shapiro-Wilk's test was used to verify the data normality, and in case of normality, the Student's *t*-test for independent samples was applied. The chi-square test was used to analyze the categorical data expressed in frequencies. A 5% significance level was adopted for all analyses.

Based on a sample test performed for the MEP pilot values of the present study, using means and standard deviations of both groups, with an 80% power and a 5% significance level, and using the *t*-test, it was determined that 19 volunteers would be needed in each group. The sample calculation was obtained using the software BioEstat, version 5.3.

RESULTS

Thirty-four volunteers were selected for this study. However, eight were excluded: seven refused to participate and one was a smoker. Therefore, 26 volunteers of both genders took part in this study, with 13 in the Sedentary Group (SG) and 13 in the AG represented in Figure 1.

The sample characteristics, presented in Table 1, show homogeneity of the variables. Table 2 presents results for the comparison of dependent variables between groups; the AG had values greater of cirtometry compared to the SG (56.4% higher in CAx, 83.4% in CX and 63.5% in CAb) and higher values of MEP (41.3% higher in absolute MEP and 39.5% of MEP in predicted %). The MIP (cmH_2O and predicted %) did not differ between groups.

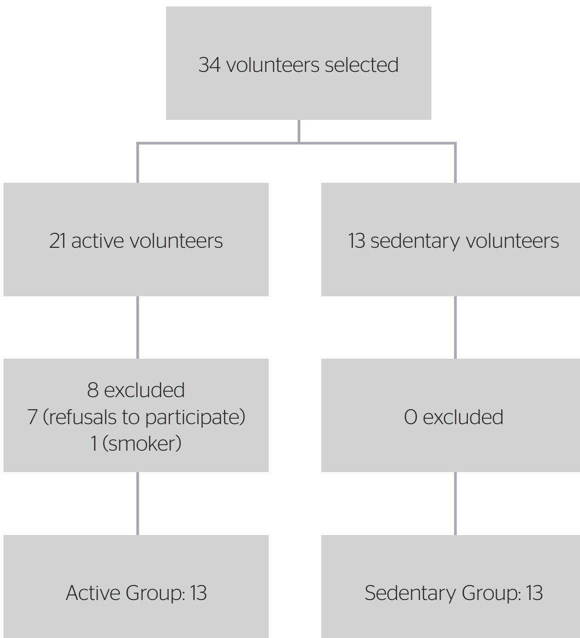

Figure 1. Flowchart of volunteer participation in the study

Table 1. Gender and anthropometrics characteristics of both groups, and period of adapted volleyball practice of the Active Group. The values are expressed in mean and standard deviation

Variables	Active Group (n=13)	Sedentary Group (n=13)	p-value
Gender (F/M)	8/5	7/6	0.714
Age (years)	64.54±6.2	66.08±9.81	0.637
Body mass (kg)	72.01±11.93	71.15±11.10	0.850
Height (cm)	167.07±7.62	167.84±9.46	0.821
BMI (kg/m^2)	25.73±3.59	25.25±3.53	0.734
Time of adapted volleyball practice (months)	54±27.49	–	–

F: female; M: male; BMI: Body Mass Index

Table 2. Comparison between thoracoabdominal cirtometry and respiratory muscle strength groups. The values are expressed in mean and standard deviation

Variables	Active Group (n=13)	Sedentary Group (n=13)	p-value
CAx (cm)	7.15±1.71	4.57±2.41	0.004
CX (cm)	7.19±2.71	3.92±1.69	0.001
CAb (cm)	4.84±2.07	2.96±1.39	0.012
MIP (cmH_2O)	87.69±22.78	77.30±8.26	0.135
MEP (cmH_2O)	143.07±58.79	101.23±28.93	0.030
MIP (% predicted)[a]	98.04±15.55	88.11±13.27	0.093
MEP (% predicted)[a]	155.78±43.63	111.61±23.97	0.004

CAx: axillary cirtometry; CX: xiphoid cirtometry; CAb: abdominal cirtometry; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure; [a]predicted percentage based on Neder et al.[22]

DISCUSSION

Results show that the adapted volleyball group presented greater thoracic and abdominal mobilities and higher expiratory muscle strength levels.

A number of studies has shown the deleterious effects of aging on different systems[1,12,14,23,24]. However, regular physical exercise during the aging process may be related to better functional capacity and quality of life[25,26], as well as to a delay or an attenuation of the normal deterioration of the respiratory muscle strength, according to maximal respiratory pressures[17].

Even though it was not the objective of this study, literature reports that there may be an association between functional capacity[27], quality of life for elderly individuals, and respiratory muscle strength[28]. Results showed that physical activity seems to lessen muscle loss due to the aging process, since the expiratory muscle strength was greater in the AG. These results are corroborated by other studies, showing that physical activity during aging acts as a protective factor against cognitive decline and dementia[29-31].

A previously study concluded that the aging process is followed by a loss of muscle mass and, consequently, gradative loss of muscle strength and thoracoabdominal mobility; however, these may be lower in individuals who exercise[24]. In the present study, both groups presented normal values for respiratory muscle strength, according to the equation proposed by Neder et al.[22] for a healthy population. Nevertheless, when the absolute values and those as the predicted percentage were compared between the active and the sedentary groups, there was a significant difference regarding maximal expiratory pressure, which was higher for the AG. This could be explained by the type of physical activity performed by the group, since the abdominal muscles are frequently required to perform tasks in adapted volleyball, and such tasks were part of the technical exercises carried out by the studied team[19]. A research[27] showed, like the present study, that physical activity, even when it is not specific for the respiratory muscles, can improve maximal expiratory pressure by working the peripheral muscles.

An investigation demonstrated a progressive and significant reduction of maximal inspiratory and expiratory pressures with aging[24] as did the other study, using maximal transdiaphragmatic pressure, which showed losses from 0.8 to 2.7 cmH_2O in maximal inspiratory pressure in subjects between 65 and 85 years of age[23,16]. However, even though literature reports a decrease asssociated with aging, no such reduction was found in either group. This fact may be perhaps explained by the age range of the volunteers, whose lower limit was below that of the age range evaluated by the mentioned authors.

Following this same context, it has been reported that there is a reduction in thoracic distensibility with aging[14], however, this loss was significantly lower in the AG, as a result of physical exercise, as previously described in a number of studies[7,17,30,31].

Rigidity of the rib cage, which occurs with aging, happens due to processes of calcification and arthritis of the costovertebral joint and can lead to a diaphragmatic respiratory pattern[32]; therefore, individuals may have limitations when subjected to an activity with greater expenditure of energy, since the thoracic muscles are requested. Moreover, with age there is increased thoracic kyphosis due to degenerative factors, both muscle and intervertebral discs, causing even greater restriction of mobility thoracic[33].

In the case of the volunteers in this study, adapted volleyball, which combines exercises of the lower limbs and stretching of the musculature that involves the thorax, can contribute to a better posture and movement of the rib cage. They presented up to 83% higher mobility compared to sedentary individuals.

This study was limited by the fact that the ideal number of participants (sample calculation) was not reached, since the sample presented here was part of a single adapted volleyball team with a limited number of players (the recreative center has only 13 participants).

Further studies about this should be conducted in order to verify the benefits of different sports in lung function and its long-term benefits.

CONCLUSION

It can be concluded that physical exercises may have increased the thoracoabdominal mobility in all levels and in the expiratory muscle strength of elderly and adults. This reinforces the idea that physical exercises have beneficial effects on the respiratory system of adults and elderly, attenuating the deleterious effects inherent in aging.

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