Biomedical Research 2017; 28 (2): 620-624

ISSN 0970-938X
www.biomedres.info

The effect of fatigue exercise on the electromyogram (EMG) and balance performance of individuals with mental disability.

Elif Top*

Faculty of Sport Sciences, Usak University, Usak, Turkey

Abstract

The purpose of the present study was to determine how the fatigue exercise affects the balance performance of individuals with mental disability, to evaluate the changes in their balance performance and electromyogram (EMG) during exercise, and to compare their values with those of healthy individuals. Educable mentally disabled individuals (n=14) and healthy sedentary individuals (n=14) were included in the study. Group 1: Included healthy balance and EMG control group, Group 2: Included the healthy individuals who were directed to perform fatigue exercise and from which EMG results were taken by means of balance scores, Group 3: Included the mild mentally disabled balance and EMG control group, and Group 4: Included the mild mentally disabled group who were directed to do fatigue exercises and from which balance and EMG results were taken. The subjects did the fatigue exercise only once for a period of 3 minutes at the submaximal intensity on the bicycle ergometer. While no differences were found within the pairs of groups, differences were found between the groups of healthy individuals and groups of mentally disabled individuals in terms of the balance parameter. On the other hand, no significant difference was found in the EMG changes in the Vastus Lateralis and Rectus Femoris muscles. When the EMG data and the heart rates recorded during the 3-minute exercise carried out with bicycle ergometer were examined, while no significant difference was found between the groups, significant differences were found between the distance, power and work values of these groups. Consequently, it was determined that there was a difference between the mentally disabled individuals and the healthy individuals of the same age group in terms of balance parameters; that physical exercise noticeably decreased the balance performance; and that mentally disabled individuals could get exhausted more quickly than their peers.

Keywords: Exercise, Mental disability, Balance, Electromyogram.

Accepted on June 8, 2016

Introduction

Cogitanti Fatigue is a rather complex concept having a very effective role in the central nervous system and the muscles and it contains physiological as well as psychological factors [1]. Muscle fatigue is expressed as a decrease in the maximal strength production of the muscle and a drop in its capacity of carrying out work [2]. Fatigue also causes the strength and power produced by muscles to decrease. The failure in maintaining the maximal power can have an effect on fatigue and the central fatigue, which prevents the voluntary contraction of muscles. The central muscle fatigue affects the control in an adverse way. Fatigue takes place especially at the muscle level and is affected by two mechanisms each of which occurs at different times. The first level of the emergence of fatigue results from the lack of ATP and the decrease in the pH level, which are related to the metabolic changes in muscles. This effect is a short-term one, disappearing in a few minutes following the termination of the exercise. In the second level, however, a muscle fatigue resulting from the failure of the contraction mechanism takes place, which results from the central nervous system. Here, a central fatigue resulting from the decreased nervous transmission to the muscles is in question [3] and it is usually caused by prolonged exercise [4]. Balance is accepted to be a complex situation obtained by means of the coordination of a number of biomechanical, sensory and motor components. Although balance is often thought as a static process, in fact it is a highly integrated dynamic process including many neurological paths [5]. Balance, which affects the functions and performance, requires the coordinated activation of the joints, muscles and visual and audial receptors in order to maintain the stability of the centre of gravity of the body. Skin, joint capsules, ligaments and muscle fibres all contribute to the maintenance of balance [6,7]. The physical fitness levels of the individuals with mental disability are accepted to be lower comparing to their healthy peers [8]. Disabled individuals face an extra health risk due to their sedentary life style as well [9]. According to some researchers, the sedentary lifestyle among children with mental disability might result from inadequate motor activity and physical fitness. It has been stated that the competence in movement is important in participation in activities [10]. Being able to maintain the daily life activities and being able to move without the help of other people are important, and it has been reported that the incidence of walking and balance problems are common among the individuals with mental disability [11].

The purpose of the present study is to determine how fatigue exercise affects the balance performance of the individuals with mental disability and to evaluate the changes in balance performances and the electromyogram (EMG) during exercise and the differences with the healthy individuals.

Materials and Methods

Study group

A total of twenty-eight people, including 14 educable mentally disabled individuals and 14 non-disabled healthy sedentary individuals, who do not get regular exercise in an active way, who had accepted to take part in the study on a voluntary basis, having no missing or damaged organs, with the same feeding habits in general, not using alcohol, drugs or similar narcotic substances, and not having any vestibular-visual disease or any serious lower or upper extremity injuries within the last six months were included in the study.

The individuals taking part in the study, as well as their families, were informed in detail about the content, objectives, methods place, time and duration of the study. Consent forms were sent to the families of all participants and their written approval about the participation of their children in the study were received. The families were also informed that their children's participation was on a voluntary basis and they could leave at any stage of the study if they wanted.

The study is a descriptive one limited with the data obtained from these individuals, having a cross-sectional quality. The study was carried out after the approval of the Scientific Research and Publications Ethical Committee of Dumlupınar University had been obtained.

Study protocol

The individuals were divided into 4 groups by random selection within the categories (n=7):

Group 1: The Healthy balance and EMG Group who do not get regular exercise;

Group 2: The Healthy Exercise Group who do not get regular exercise, who are subjected to a 3-minute fatigue exercise and from which balance parameters and EMG results are taken at the end of the exercise;

Group 3: The Mildly Mentally Disabled Balance and EMG Group who do not get regular exercise;

Group 4: The Mildly Mentally Disabled Exercise Group who do not get regular exercise, who are subjected to a 3-minute fatigue exercise and from which balance parameters and EMG results are taken at the end of the exercise (Table 1).

Table 1. Physical Properties of the Groups.

Groups	Age (years)	Height (cm)	Weight (kg)	Body-Mass Index
Group 1	17.00 ± 0.01	173.00 ± 0.03	63.08 ± 8.93	21.67 ± 2.57
Group 2	17.28 ± 0.48	175.86 ± 0.08	68.37 ± 11.94	22.24 ± 4.44
Group 3	16.71 ± 0.95	163.00 ± 0.10	63.15 ± 17.87	24.04 ± 8.13
Group 4	17.20 ± 1.30	169.20 ± 0.05	57.48 ± 7.07	19.40 ± 2.56

Body measurements

Body measurements were carried out by means of the Jawon Make body composition analyser (Model IOI-353). The device is a system which carries out a leg-to-leg analysis with 5, 50 and 250 KHz frequency and which have a clean steel surface on which bare feet contact [12]. The weights were measured when the participant were wearing light clothes and barefooted, and with a precision ratio of 0.1.

Intelligence level

Before starting the study, Weschler Intelligence Scale test was applied by the Guidance and Research Centre. Participants' scores in the intelligence tests have not been given due to ethical reasons and, instead, educational diagnoses have been given. The results of these diagnoses showed that the disabled individuals participating in the study were at the educable intelligence level.

EMG measurement protocol

A literature review was carried out about the leg region and the Vastus Lateralis (VL) and Rectus Femoris (RF) muscles were included in the research. Before the electrodes were placed on the muscles, the surface of the skin had been cleaned with alcohol. The electrodes were placed towards the middle section of the muscle for the RF muscle, and to the lateral section of the muscle for the VL muscles. The reference electrode was placed on the soleus muscle. The vibration was applied for 1 minute. The electrode pair was placed away from each other approximately 2 cm. The electrode size was 5 × 5 cm. The resting myoelectrical activity was expressed as microvolt (μV). It was measured using a surface EMG device (NeuroTrac, Verity Medical, UK. EMG range: 0.2 to 2000 μV RMS, sensitivity: 0.1 μV RMS, Notch filter: 50 Hz, Common mode rejection ratio: 130 dBs). Vibrations generated peculiar, non-negligible motion artefacts on skin electrodes, resulting in an over estimation of muscular activity. An appropriate filtering has been suggested to obtain artefact free signals from muscle. Therefore, the selected band pass filter was 100-370 Hz [13].

Balance test

Balance ability was evaluated through the balance test using the Libra board (Easytech, Prato, Italy). This instrument (42 ×

42 cm, weight 2.7 kg) consists of a balancing board with a wide antisliparea. A moderate degree of difficulty was set, with the board plug placed at 40 cm. A Libra board is connected to a personal computer, and Balance ability can be assessed with appropriate software (Libra software). Subjects were asked to fixate on a point on the wall, in the eye plane, at a distance of 3 m. The Libra board software returns the outcomes in arbitrary units. The scores range between 0 and 100, and the better results are closer to 0. The same instrument and the same protocol have been used in other studies [14].

The performance of the fatigue exercise

The Groups 2 and 4 got the fatigue exercises on a bicycle ergometer in the form of a 3-minute aerobic submaximal exercise. During the performance of the submaximal exercise, it was ensured that the heart rate values of the Group 2 and Group 4 were equal. All cycle testing was performed on an air-braked cycle ergometer (Watt bike Ltd, Nottingham, UK). The Watt bike calculates power output by measuring the chain tension over a load cell (sampled at 100 Hz) and the angular velocity of the crank arms (twice per revolution). The reliability of the Watt bike cycle ergometer has been reported previously over a range of power outputs (50-300 W), with a CV of 2.6% (95% CI 0.7-2.0%) in trained cyclists [15]. During the exercise test, heart rate was recorded continuously using a RS300X heart-rate monitor (Polar Electro Oy, Kempele, Finland).

Statistical analysis

In the statistical evaluation, the arithmetic mean and standard deviations of the data were calculated. The obtained parameters were applied to a homogeneity test. The one-way analysis of variance was used in the comparison of the parametric data. In the cases where significant differences were found, LSD (Least Significant Difference) test was used to determine the differences between the groups. The EMG results of the groups performing the fatigue exercise were evaluated by means of the Independent Samples T-Test. IBM SPSS 21.0 "Statistical Package for the Social Sciences" packaged software was used in the analyses, and the significance level was found to be $p \leq 0.05$.

Results

In the present study, when the balance and the EMG variations during the balance were examined, it was seen that the best balance scores were obtained by the healthy balance group (Group 1), the second best balance scores were obtained by the health group performing the fatigue exercise (Group 2), but there was no statistically significant difference between these two groups. While the lowest balance score belonged to the control group (Group 3) among the disabled groups, it was found that there was a statistically significant difference between the balance score of this group and that of the health balance group ($p<0.05$), that the fatigue exercise increased the balance score, however there was no statistically significant difference between them (between Group 2 and Group 4) ($p>0.05$). On the other hand, significant differences were found between the groups getting fatigue exercise/Group 2 and Group 4 ($p<0.05$). No significant differences were found between the EMG variations in the VL and RF muscles measured during the balance ($p>0.05$) as shown in Table 2.

In the present study, when the EMG data and heart rates recorded during the 3-minute exercise performed with the bicycle ergometer were examined, no significant differences were found between the groups (Groups 2 and 4) ($p>0.05$), while a significant difference was found between the Distance, Power and Work values of these groups ($p<0.05$) as shown in Table 3.

Table 2. *The balance values of groups and their EMG values during the balance.*

Groups	Group 1	Group 2	Group 3	Group 4	F	p
Balance	19.92 ± 2.86a	23.05 ± 3.81ab	27.25 ± 4.22bc	30.16 ± 6.94c	6.362	.003*
EMG/VL (μV)	51.88 ± 30.21	47.27 ± 19.30	33.94 ± 24.63	34.31 ± 17.54	1.003	0.409
EMG/RF (μV)	65.48 ± 38.59	58.57 ± 23.47	41.77 ± 25.89	43.41 ± 17.81	1.176	0.341
p<0.05*						

Table 3. *The EMG, power, work and heart rate values of the groups during exercise.*

Groups	Group 2	Group 4	t	p
EMG/VL (μV)	130.64 ± 40.51	104.40 ± 28.37	1.328	0.211
EMG/RF (μV)	201.85 ± 101.32	173.26 ± 64.62	0.593	0.565
Distance	1680.71 ± 103.03	1496.33 ± 101.27	3.242	.008*
Power	158.38 ± 25.73	122.83 ± 21.50	2.673	.022*
Work	160.02 ± 18.65	134.33 ± 15.16	2.692	.021*
Heart Rate	163.00 ± 6.50	166.33 ± 5.88	-0.961	0.357
*p<0.05				

Discussion

In terms of motor development, individuals with mental disability follow their healthy peers from far behind. The balance performance, which is supposed to develop depending on the age, is also lower among the individuals with mental disability than the normal level. The balance is of great importance for all people whether they are individuals with mental disability or healthy normal individuals, and it serves as the foundation for all movements. Performing all the movements of daily life is possible only through the proper posture and the balance [16]. The results of the present study showed that the best balance scores were obtained in the healthy balance group (Group 1), the second best balance scores were obtained by the healthy group performing fatigue exercise (Group 2), however there was no statistically significant difference between them. While the best balance score obtained by the control group (Group 3) among the disabled groups, it was found that there was a statistically significant difference between this group and the healthy balance group ($p<0.05$), that the fatigue exercise negatively affected the balance score (Group 4), however there was no statistically significant difference between these two groups (Group 2 and Group 4) ($p>0.05$). On the other hand, a statistically significant difference was found between the groups which performed fatigue exercise (Group 2 and Group 4) ($p<0.05$). This is an indication of the fact that there is a significant difference between the healthy individuals and the educable individuals with mental disability of the same age group in terms of the parameter of balance and though statistically not significant, balance is affected by fatigue exercise when considered on the basis of scores. In fact, previous studies have emphasized that a lack of dynamic balance is in question among the individuals with mental disability and that development of balance skills is of great importance for these individuals [17]. It has also been reported in similar studies that the children with mental disability perform more poorly in terms of physical and motor fitness skills such as power, agility, balance, running and speed. Research has shown that the individuals with disability cannot develop in terms of their balance performance in parallel with the increase in their age and are affected by that; displaying losses mostly in their coordination, balance and speed skills [18,19]. Although no significant difference was found when the EMG values was measured during the balance performance of the groups, a significant difference in terms of muscle activities has been observed among them as shown in Table 2. This difference has been observed during the fatigue exercise as well shown in Table 3. When the previous studies were reviewed, it was seen in a clear way that normal individuals and the individuals with mental disability had similar muscle transmission and power, and that similar results had been obtained in these studies as well [20,21]. However, the most notable results obtained in the present study are the ones concerning the Distance, Power and Work. When these parameters were examined, significant differences were found between the healthy individuals and the individuals with mental disability ($p<0.05$) as shown in Table 3. Although equal loads were applied to the individuals with mental disability and the healthy individuals at the same heart rate, it was found that the individuals with disability were behind the healthy individuals in terms of Distance, Power and Work, and that they had higher heart rates in spite the fact that they had lower values of power and distance. This means that less workloads cause higher heart rates and earlier fatigue among the individuals with mental disability comparing to the healthy individuals. Fatigue weakens the proprioceptive and kinaesthetic properties of joints and increases the threshold of muscle fibre discharge, and thus, joint sensitivity develops and feedback is disrupted [22,23], resulting in a decrease in the ability to maintain the balance [24,25].

Consequently, it has been determined that there are differences between the individuals with mental disability and the healthy individuals of the same age group in terms of their balance parameters, and that tiring physical exercises noticeably decrease the balance performances of both health individuals and the individuals with mental disability. Moreover, the individuals with mental disability displayed signs of exhaustion earlier comparing to their healthy peers. Early exhaustion is a factor adversely affecting the balance. Performing the daily activities in a controlled way is closely associated with the balance. The functional independence of individuals is possible only with the systematic and proper working of all body parts. In this context, it is considered that the people dealing with children with mild mental disability should consider the parameters constituting the balance in detail and add more balance-promoting exercises into their programs. Since overloads during the exercises performed by disabled individuals may cause a decline in their ability of balance, they can increase the risk of injury. Thus, while getting the individuals with mental disability to perform exercises, the exercises intended to increase the ability of balance should also be included in their training planning.

References

1. McKenna MJ. Mechanisms of Muscle Fatigue. In Physiological Bases of Sport Performance. New South Wales 2003.
2. Fitts RH. Cellular mechanisms of muscle fatigue. Physiological Reviews 1994; 74: 49-94.
3. Gandevia SC. Spinal and supraspinal factors in human muscle fatigue. Physiol Rev 2001; 81: 1725-1789.
4. Bizid R, Margnes E, François Y, Jully JL, Gonzalez G, Dupui P, Paillard T. Effects of knee and ankle muscle fatigue on postural control in the unipedal stance. Eur J Appl Physiol 2009; 106: 375-380.
5. Erkmen N, Taskin H, Sanioglu A, Kaplan T. The effects of fatigue on balance performance in soccer players. J New W Sci Acad Sp Sci 2009; 4: 289-299.
6. Johnston R, Howard ME, Cawley PW, Lossee GM. Effect of lower extremity muscular fatigue on motor control performance. Med Sci Sports Exerc 1998; 30: 1703-1707.
7. Trop H. Pronator muscle weakness in functional instability of the ankle joint. Int J Sports Med 1986; 7: 291-294.
8. Pitetti KH, Beets MW, Combs C. Physical activity levels of children with intellectual disabilities during school. Medicine and Science in Sports and Exercise 2009; 41: 1580-1586.
9. Ayvazoglu NR, Ratliffe T, Kozub FM. Encouraging lifetime physical fitness. Teach Except Child 2004; 37: 16-20.
10. Okely AD, Booth ML, Chey T. Relationships between body composition and fundamental movement skills among children and adolescents. Res Quart Exerc Spo 2004; 75: 238-247.

11. Cleaver S, Hunter D, Ouellette-Kuntz H. Physical mobility limitations in adults with intellectual disabilities: A systematic review. J Intell Disab Res 2009; 53: 93-105.
12. Chen YC, Tu YK, Huang KC, Chen PC, Chu DC, Lee YL. Pathway from central obesity to childhood asthma. Physical fitness and sedentary time are leading factors. Am J Resp Critic C Medicine 2014; 189: 1194-1203.
13. Karacan I, Cidem M, Ozen A, Gun K, Uludag M, Bahadir C, Unalan H. The effects of radius bone density on the resting myoelectrical activity of contralateral wrist flexors in subjects exposed to unilateral forearm vibration. Turkiye Klinikleri J Med Sci 2012; 32: 1673-1680.
14. Boccolini G, Brazzit A, Bonfanti L, Alberti G. Using balance training to improve the performance of youth basketball players. Sport Sci Health 2013; 9: 37-42.
15. Driller MW, Argus CK, Bartram JC, Boniventura J, Martin DT, West NP, Halson SL. Reliability of a 2-bout exercise test on a wattbike cycle ergometer. Int J Sports Physiol Perform 2014; 9: 340-345.
16. Bayazit B, Fil H, Son M, Colak S, Eskiyecek CG, Colak E. The investigation of the effect on the development of balance the study programme of the gymnastics in the educable mentally handicapped girls. The J Acad Soc Sci 2014; 2: 370-377.
17. Boswell B. Comparison of two methods of improving dynamic balance of mentally retarded children. Percep Mot Ski 1991; 73: 759-764.
18. Cox CR, Clemson L, Stancliffe RJ, Durvasula S, Sherrington C. Incidence of and risk factors for falls among adults with an intellectual disability. J Intell Disabil Res 2010; 54: 1045-1057.
19. Hsieh K, Heller T, Miller AB. Risk factors for injuries and falls among adults with developmental disabilities. J Intel Disabil Res 2001; 45: 76-82.
20. Borji R, Zghal F, Zarrouk N, Sahli S, Rebai H. Individuals with intellectual disability have lower voluntary muscle activation level. Res Dev Disabil 2014; 35: 3574-81.
21. Blomqvist S, Wester A, Rehn B. Postural muscle responses and adaptations to backward platform perturbations in young people with and without intellectual disability. Gait Posture 2014; 39: 904-908.
22. Gribble PA, Hertel J, Denegar CR, Buckley WE. The effects of fatigue and chronic ankle instability on dynamic postural control. J Athle Trai 2004; 39: 321-329.
23. Akil M. Effect of acute exercises applied to sedentaries on various enzyme levels related to muscle damages. Afr J Microbiol Res 2012; 6: 284-287.
24. Johnston RB, Howard ME, Cawley PW, Losse GM. Effect of lower extremity muscular fatigue on motor control performance. Med Sci Sports Exerc 1998; 30: 1703-1707.
25. Lepers R, Bigard AX, Diard JP, Gouteyron JF, Guezennec CY. Posture control after prolonged exercise. Eur J Appl Physiol 1997; 76: 55-61.

*Correspondence to

Elif TOP

Department of Sport Sciences

Usak University

Turkey