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Effects of a low carbohydrate diet on sports performance

NEMANJA REBIĆ, VLADIMIR ILIĆ, IGOR ZLATOVIĆ

Abstract
Although high carbohydrate intake (>60%) is generally recommended for athletes, nowadays many experiments involve a low carbohydrate diet. Carbohydrate restriction leads to significant hormonal changes as well as reduced glucose utilization and increased utilization of free fatty acids and ketone bodies as energy sources. This narrative review aimed to discuss the physiological basis of low carbohydrate ketogenic diets (LCKD) and their both positive and negative effects on body composition, power, strength, aerobic capacity and anaerobic performance of athletes and physically active subjects. We searched and analyzed earlier and recently published papers on the subject. Research results showed that LCKD facilitates a reduction of body mass and fat mass while promoting maintenance of lean body mass (LBM). However, compared to a diet with a high carbohydrate content, it is challenging to increase LBM. Despite significant metabolic changes and increased fat oxidation LCKD did not show clear and convincing effects on endurance ability. While LCKD can preserve endurance performance in sports where intensity does not exceed 65-70% VO_2max, it is not superior compared to a diet high in carbohydrates. Also negative effects on aerobic capacity can be manifested, especially in women, which may be related to a lower status and transport of iron and due to the difference in fat oxidation between genders. Reduced availability of glucose, decreased glycolytic enzyme activity and metabolic inefficiency (higher oxygen consumption for fat oxidation compared to glucose oxidation) might impair anaerobic performance where the intensity exceeds 70-80%. It seems that LCKD has no particular effects on maximum strength, power and anaerobic lactate abilities because they depend on the phosphagen energy system.

KEYWORDS: sports performance, low carbohydrate diet, body composition, keto diet.

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Introduction

The application of a properly programmed diet in athletes is an extremely important factor that contributes to the achievement of sports results, because it greatly affects physical abilities, body composition, speed of recovery, replenishment of spent energy depots, electrolytes, etc. According to previous recommendations, the largest part of an athlete's diet should contain carbohydrates (CHO), which account for more than 60% of daily calorie intake [17]. Carbohydrates stored in the liver and muscles as glycogen are a readily available source of energy for prolonged moderate intensity physical activities and the primary source of energy for high-intensity physical activities (>80% of maximum oxygen consumption – VO_2max) [27]. In addition, carbohydrates lead to an increased level in the anabolic hormone insulin and thus contribute to muscle protein synthesis and prevent muscle protein breakdown [1]. On the other hand, in athletes fat intake should not be higher than 30%, while the general recommendation for protein intake is 1.4-1.8 g/kg/d [17]. However, regardless of the recommendations above some researchers have postulated that in certain cases a low carbohydrate diet, with high fat and/or protein contents may also be equally or even more effective than the standard diet recommended for athletes [43]. A diet based on a low carbohydrate intake has generally been distinguished from the ketogenic diet. A low carbohydrate ketogenic diet (LCKD) leads to ketosis, i.e. increased production of ketone bodies, while a low carbohydrate diet (LCD) is any diet that reduces carbohydrate intake (usually below 200 g), but does not necessarily lead to ketosis [1]. Restriction of carbohydrate intake leads to changes in metabolism by shifting it from "glucocentric" to "adipocentric", namely, there is a reduced use of glucose as an energy source and an increased use of free fatty acids (FFA) and ketone bodies (from food fats, protein and the adipose tissue) [1]. The functioning of tissues, for which glucose is necessary (red blood cells, retina, lens, kidney medulla, central nervous system), is maintained through gluconeogenesis and glycogenolysis. Even though no carbohydrates are ingested, the body will make 200 g of glucose a day only through the liver and kidneys, mostly from amino acids (alanine and glutamine) and less from glycerol, pyruvate and lactate [1, 48]. However, when gluconeogenesis fails to keep pace with bodily needs for glucose, the production of ketone bodies from FFA in the liver increases. After fatty acids are released from the adipose tissue, they are transported to the liver, where they are transformed by the process of β-oxidation into acetyl-CoA, which can be oxidized in the citric acid cycle or used to obtain ketone bodies. By a further process and action of certain enzymes, three ketone bodies are formed, with acetic acid (AcAc) being formed first, followed by beta-hydroxybutyric acid (BHB) and acetone [1]. When BHB values exceed 0.5 mmol/L, nutritional ketosis is observed. Then ketone bodies replace glucose and become the primary source of energy for the brain and nerve cells. Also, BHB and AcAc are optimal substrates for muscle tissue and are rapidly oxidized [1]. Therefore the energy sources during LCKD are fatty acids (70% of caloric requirements from dietary fat and lipolysis of adipose tissue pools), KBs (20% of caloric requirements from lipolysis and ketogenesis adipose stores), and glucose (10% of calorie requirements from gluconeogenesis) [1]. Besides, studies have shown that LCKD results in the reduction of total carbohydrate oxidation and a 2-3-fold increase in whole-body fat oxidation and lipolysis during steady-state aerobic exercise [5, 43, 47]. This proportion of energy contribution and changes in substrate oxidation has led to assumptions that LCKD may be beneficial for prolonged endurance activities, since they rely predominantly on fat [43]. On the other hand, a decrease in the oxidation and availability of glucose may negatively affect high-intensity activities (>70/80% VO_2max), where carbohydrates are the primary source of energy [11, 50]. Also, the effect of LCKD on lean body mass (LBM) is highly questionable because ketosis is a physiological process that acts catabolically, which is manifested by increased levels of adrenaline, cortisol [19] and glucagon at a decrease in insulin levels [42, 48, 52]. In addition, LCKD inhibits the mTOR signaling pathway, which is responsible for protein synthesis and muscle mass increase [1, 28]. On the other hand, it has been shown that BHB has a proteolytic effect [40] and that LCKD leads to an increase of the levels of some anabolic hormones such as testosterone, growth hormone [25, 42] and IGF-1 [13], potentially having a positive effect on LBM. Maintaining optimal LBM values is extremely important for athletes, as its reduction could negatively affect sports performance. In view of the above, this narrative review aims to discuss the physiological basis for low carb ketogenic diets and their both positive and negative effect on body composition, power, strength, aerobic capacity and anaerobic performance in athletes and physically active subjects.

Adaptation of athletes to LCKD

When switching to LCKD, athletes should adapt to an increased use of fatty acids and ketone bodies at a reduced use of carbohydrates as a previously dominant energy source. The rate of fatty acid oxidation increases significantly during the first week and in the following weeks it reaches maximum values of up to 1.5 g/min [4]. At the same time, it usually takes 2 to 3 weeks to reach the optimal value of ketone bodies. When the organism adapts to an increased level of ketone bodies it starts utilizing them as a source of energy. In athletes constant values of beta-hydroxybutyrate were reported to exceed 0.5 mmol/L of blood, which was sufficient to achieve nutritional ketosis [34, 44], although some other authors found higher values (from 1 to 3 mmol/L) [1]. During this transition, which is extremely difficult and can last from 7 to 20 days, athletes experience a decrease in physical abilities and an increase in the subjective feeling of fatigue. Additionally, nerve cells work less efficiently, which makes it difficult to concentrate and efficiently perform high-intensity technical tasks [4, 52]. However, when athletes adapt to this diet they can function effectively without their physical abilities being impaired [4, 43].

The effect of LCKD on body composition in athletes

In order to show maximum performance and achieve a competitive result it is very important to have an optimal body composition, which in athletes in almost all sports should contain a low percentage of fat mass and high LBM. Low-fat mass is associated with higher aerobic potential [9] and high LBM with maximum strength [23], power, explosiveness, speed and other abilities [6]. Additionally, achieving an optimal body composition is crucial for participation in aesthetic sports, such as fitness and bodybuilding, but also in sports categorized according to body weight, such as combat sports [28]. Especially in these sports athletes try to reach an ideal weight within a very short time, so they often rely on some extreme methods (use of salted baths, saunas, diuretics, laxatives, etc.) and/or extremely energy-restrictive diets, mainly requiring reduced carbohydrate intake [28]. Reduction in carbohydrate intake or application of LCKD due to significant metabolic effects, manifested in increased lipolysis of adipose tissue and increased water excretion, results in a very rapid reduction of body mass and fat mass, which can lead to optimal body composition. However, in the long term when caloric intake was uniform LCKD compared to the standard diet did not show better effects on weight and fat reduction in either the general population or athletes [1]. Also, rapid changes in body composition can lead to some side effects, such as dehydration, electrolyte imbalance, cardiac arrhythmias, fatigue and psychological difficulties, etc. [1, 28]. Such effects combined with intensely strenuous training and competitions, which also have a stressful and catabolic effect on the athlete's body, can lead to a drop in LBM and physical abilities [22]. It is very difficult to maintain and even more difficult to increase muscle mass on a ketogenic diet. The state of ketosis is very similar to the state of starvation when the activity of metabolic mechanisms stimulating autophagy and catabolic processes occurs [1, 28]. Under such conditions there is an increased activity of the enzyme 5 adenosine monophosphate-activated protein kinase – AMPK. This enzyme has a catabolic effect, it inhibits the activity of the mammalian target of the rapamycin signaling pathway – mTOR, and thus prevents protein synthesis and increases muscle mass [26, 28]. Oxaloacetic acid is another limiting factor for adding muscle mass, but also for complete oxidation of fat on a ketogenic diet. In the absence of glucose there is not enough oxaloacetic acid, which is necessary to start the cascade of the Krebs cycle in interaction with acetyl CoA. To maintain the function of the citric acid cycle, oxaloacetate must be provided by deamination of glucogenic amino acids such as aspartate and asparagine, which consequently leads to protein resynthesis and reduction of muscle mass [1, 28]. Most studies, which examined the influence of LCKD on the body composition of athletes, in addition to the decrease in body mass and fat mass also recorded a decrease in muscle mass, i.e. LBM. In a study on taekwondo athletes the use of LCKD, in which a caloric deficit of 25% was observed, in addition to a decrease in body mass and fat mass led to a decrease in LBM (from 54.7 ± 3.9 to 52.5 ± 4.7 kg; $p < 0.05$) [32]. Taekwondo practitioners trained as much as 5 hours per day, of which 2 hours were strength development exercises, 1 hour of low-intensity morning exercises and 2 hours of specific exercises for taekwondo athletes. Similarly, another study on crossfitters, which showed a decrease in energy intake (~500 kcal), after 12 weeks resulted in a 1.4% decrease in LBM of leg muscles and an 8% decrease in the thickness of m. vastus lateralis [16]. The results of these studies can be attributed to the combined catabolic effects of intense and extensive exercise, ketosis and energy deficit. However, even when energy intake was uniform in highly trained powerlifters and Olympic weightlifters (9 male, 5 female), administration of LCKD for 3 months resulted in a significant decrease in body mass (–1.7 kg) and LBM (–1.7 kg), while the standard diet phase increased body mass (+1.6, difference 3.3 kg) and LBM (+0.6 kg, difference 2.3 kg) [12]. In this study the differences in LBM can be explained by a significantly lower carbohydrate intake, which consequently led to increased catabolic effects, but also to redistribution and excretion of water due to diuresis, which is increased on LCKD due to glycogen loss and ketonuria. Approximately 100 g of glycogen is stored in the liver, while 400 g is stored in the muscles, with each stored gram associated with 2 g of water [38]. Additionally, the decrease in LBM was also connected by a slightly lower protein intake, which in the above-mentioned studies ranged from 1 to 1.5 g/kg. According to Kerksick et al. (2018), in order to maintain or add muscle mass, protein intake in athletes must be 1.4-2.0 g/kg [17]. However, contrary to previous results preservation or even a slight increase in muscle mass after the application of LCKD was reported in several studies. In a study of top gymnasts regularly performing strength exercises after a month of LCKD there was a significant reduction in body weight and fat mass, but not LBM (–1.1 kg; $p > 0.05$; although the % LBM increased by 2.6%). On the other hand, in the group administered a standard diet

LBM increased by 300 g. However, it is important to keep in mind that that study was conducted on only 9 male gymnasts [29]. In a study of Volek et al. (2002), after the application of LCKD for 6 weeks a decrease in fat mass (–3.4 kg) and an increase in LBM (+1.1 kg) were reported in physically active subjects [46]. In another study cited by Volek et al., administration of LCKD in combination with resistance training for 12 weeks decreased fat mass by 7.7 kg, and increased LBM by 1 kg, while the group on the standard diet increased LBM by 1.8 kg [45]. What is common to these studies, which can explain the differences from previous results, is the application of resistance training, optimal energy intake and adequate protein intake, which was generally about 2 g/kg. The control groups from these studies had the same energy intake and an adequate protein intake, but significantly higher carbohydrate intake, which is most likely the reason for the significantly higher growth of LBM compared to subjects on LCKD. Phinney (2004) found that combined carbohydrate and protein intake preserved LBM (which was assessed by nitrogen balance), while those who consume protein alone experienced progressive loss of body nitrogen [30]. Intake of glucose and amino acids in combination (especially leucine) activates the mTOR signaling pathway and has an anabolic effect on muscle mass [28]. Therefore, athletes are generally advised to consume a meal rich in carbohydrates and proteins after training. Considering that in all the above-mentioned studies the subjects applied resistance training or strength exercises in combination with other types of physical activity, we can say that such activities themselves act catabolically and lead to degradation of muscle tissue. Whether anabolic effects on muscle mass growth are achieved during the recovery period depends on the amount of energy intake and a combination of nutrients after training. However, most studies show that despite both the application of resistance training and the fact that the respondents are athletes who compete in strength sports, they still lose a significant amount of body weight from LBM (on average 34%) [1]. In turn, the increase in LBM was observed in only two studies, which could be further explained by certain anabolic effects that LCKD promotes [45, 46]. Low glucose and insulin levels are associated with an increase in growth hormone [15, 25], while high protein intake is related to an increase in IGF 1 [13]. In terms of testosterone levels, the results of these studies are inconsistent. Although high fat intake and increased cholesterol in the LCKD were associated with an increase in testosterone levels [25, 42], Durkalec-Michalski et al. (2021) found no effects of LCKD on certain hormones [7]. Evidence is also available suggesting that beta-hydroxybutyrate activates the mTOR signaling pathway and prevents proteolysis [40]. These are some of the factors that, together with adequate nutrient and energy intake, may explain the maintenance or increase in LBM on LCKD. The LCKD diet can improve the body composition of athletes by reducing body weight and fat mass, but compared to the standard diet in an isocaloric situation do not show better results. Also, compared to a diet with high carbohydrate content, it is challenging to increase LBM and resistance training with adequate protein intake and minimal carbohydrate intake are necessary for muscle mass preservation or slightly increment.

Effects of LCKD on strength and power sports

Strength and power are physical abilities that primarily depend on the phosphagen energy system, so it is unlikely that changes in glucose and fat oxidation will have an impact on them. However, the LCKD could have an indirect effect here because it significantly affects body composition and LBM. However, although studies on this topic are few, they generally show that despite the reduction of LBM during LCKD, there is no decline in the strength and power of athletes. In crossfitters (5 males and 2 females) [16], powerlifters, and Olympic weightlifters (9 males and 5 females) [12], who applied LCKD for 3 months, despite a significant drop in LBM, no effect was observed on a vast majority of all measured parameters that assessed strength and power (the power to weight ratio, 1RM – one repetition maximum of squat, clean and jerk, snatch, push-up, chest push-up, deadlift), except for the maximum number of push-ups, where progress was recorded ($p < 0.05$). It is possible that no drop in performance may have been caused by the fact that LBM did not decrease due to degradation of muscle tissue, but due to redistribution of body fluids, as those authors reported. Also, the production of maximum force largely depends on the amount of ATP in the muscle and its resynthesis via the phosphagen rather than the glycolytic system [10]. 1RM is performed after a complete repair, which allows enough time to compensate for the oxygen consumed and resynthesize adenosine triphosphate (ATP) and creatine phosphate (CP). Furthermore, protein intake in those studies ranged from 1.1 to 1.5 g/kg, which was not in line with the general recommendations for strength athletes amounting to 1.7 g/kg [39]. On the contrary, high protein intake (2.8 g/kg) with electrolyte supplementation maintained nitrogen balance and preserved LBM in top male gymnasts, which indirectly affected the preservation of performance that is important for gymnastics (squat jumps, countermovement jumps, reverse grip chin-ups, push-ups, legs closed barrier test, parallel bar dips) [29]. Although a majority of respondents in those studies were men, studies in women show similar results. In women (n = 21) who regularly performed strength exercises and whose protein intake was 1.9 g/kg, maintenance of LBM (–0.7 kg +/– 1.7; p = 0.202) and improvement in bench-press and squat strength were observed compared with the baseline. However, LBM (+0.7 +/– 1.1; p = 0.074) and strength gains were greater in the control group compared with the LCKD group [41]. Additionally, in a study of 11 women and 11 men, whose protein intake was 1.7 g, cross-fit-specific performance was maintained in both genders [7]. Considering that almost all the above-mentioned studies refer to athletes classified according to body weight, reduction in total mass and fat mass and preservation of performance despite the fall of LBM could help them to classify for a competition, but may hinder achieving a better result.

Effects of LCKD on performance in endurance sports

One of the reasons why LCKD advocates recommend its use in endurance sports is limited carbohydrate stores (~2200 kcal) compared to fat stores (~30,000 kcal in a person with 7-14% of fat mass) [44]. Adaptation to LCKD leads to a decrease in glucose oxidation, while at the same time leading to a 2- to 3-fold increase in FFA oxidation [5, 34, 43, 47]. Besides, compared to a high carbohydrate diet (HCD), LCKD achieves the maximum rate of fat oxidation at a relatively higher work intensity (1.5 g/min at about ~70% of maximum oxygen uptake – VO_2max vs ~0.7 g/min at 55% VO_2max [43], while resynthesis and glycogen levels after exercise are preserved and do not differ significantly from HCD [31, 43]. The higher fat intake through diet and adaptation to its increased use will allow the body to use fat more effectively and at a higher % of VO_2max, i.e. preserved carbohydrate reserves will later be included as a dominant energy source in the event of an increased work intensity. Despite such pronounced metabolic effects, most studies have shown that LCKD has no significant effect on endurance performance [11, 16, 24, 34], while even negative effects in certain studies have been reported [5, 7, 35, 51]. Interestingly, the decline in aerobic capacity is more common in females [7, 35, 51]. In a study of Durkalec-Michalski et al. (2021), consuming a LCKD led to an 10.4% decrease in peak oxygen uptake during ICT (p = 0.027) in females, while in males there was no significant effect. One possible explanation for VO_2 peak drop is that this study resulted in certain alterations in haematological parameters (haemoglobin – HGB, mean corpuscular HGB, and mean corpuscular HGB concentration) in females. These results may indicate a lower status and transport of iron. In females the daily iron intake was lower than the dietary recommendations for athletes [7]. Also, due to increased levels of interleukin 6 and hepcidin during LCKD iron transport may be impaired [27]. Iron is a key functional constituent of hemoglobin and myoglobin and it is required for oxygen uptake, transport and energy production [2]. A poor iron status reduces oxygen-carrying capacity of RBCs, leading to a decline in physical performance [27]. As women are biologically susceptible to a lower iron status, the reduced iron intake with a LCKD may impact women more than men [27]. Also women may possibly achieve lower VO_2 peak values after consuming LCKD due to the difference in fat oxidation between the genders. Namely, in a previous study by Durkalec-Michalski et al. (2019) it was shown that men have a higher rate of fat oxidation than women up to 80% VO_2 max and that they are more prone to shifts in macronutrient utilization (in favor of fat utilization) during submaximal intensity exercise [8]. On the other hand, in some studies positive results for the endurance of athletes have been recorded. In elite race walkers [5] and off road cyclist [50] an improvement in aerobic capacity was reported. However, in off road cyclists the increase in VO_2max in relative values (ml/kg/min) was due to body mass and fat mass reduction, while in elite race walkers it was not accompanied by an improvement in endurance performance. In another study on highly trained endurance athletes the application of LCKD for 12 weeks resulted in an improvement in the time achieved in a 100 km race by 4.1 min, while HCD improved the time by 1.1 min. This improvement was not statistically significant either relative to baseline time or between groups; moreover, the VO_2max, at which this time was achieved was not specified [24]. At an exercise intensity of less than 60-65% VO_2max metabolic efficiency is preserved, i.e. oxygen uptake is followed by an equal oxygen consumption, which along with the reduction in body weight observed in some studies may explain the preservation of performance at this intensity [24, 34]. However, in endurance sports it is often necessary to increase the intensity above 70% VO_2max [4]. Studies show that with increasing intensity LCKD impairs performance by reducing work economy. Highly trained runners [34], fast walkers [5], cyclists [50] and recreationally active men [11] showed increased oxygen consumption, increased energy expenditure and reduced lactate production. Consequently, a reduction in time achieved and reduced power output throughout the race and at the end of the race were recorded at an exercise intensity greater than 70-80% VO_2max. At an exercise intensity exceeding 70% VO_2max the carbohydrate requirement is far greater; however, due to adaptation to ketosis glycolytic enzymes are inhibited, which prevents oxidation of glycogen and glucose. Thus, for the most part the body is forced to continue to rely on fat [4]. Compared to glucose oxidation, fat oxidation requires significantly more oxygen (8%) to obtain energy [4]. It was found that even after 8 months on LCKD there is no increased activity of gluconeogenesis compared to HCD at an intensity of 72% VO_2max [47]. All this together indicates that LCKD limits the availability of glucose and increases the oxygen cost, which consequently reduces the economy of work and endurance of athletes. Thus LCKD can maintain performance at exercise intensity below 70% VO_2max, but with an increase in intensity above 70-80% VO_2max a decrease is observed in metabolic efficiency and endurance of athletes.

Effects of LCKD on anaerobic performance

In sports activities where anaerobic metabolism is dominant, energy from the phosphagen energy system and glycolysis is mainly used, so it is unlikely that a reduced rate of glucose oxidation and an increased rate of fat oxidation after LCKD adaptation will have a favorable effect on performance. In a study on physically active subjects, HCD and standard diet compared to LCD achieved greater time to failure during supramaximal work intensities (HCD – 4.4 ± 0.3 min; Control – 3.7 ± 0.3 min; LCD – 3.0 ± 0.2 min) [21]. Also Langfort et al. (1997) and Wroble et al. (2019) showed that the application of LCD for 3 and 4 days in subjects regularly training at high intensity resulted in a decreased peak power and mean power during 30 s (measured by the Wingate test) [20, 49]. Although the results of these studies can be explained by the short duration and lack of adaptation, longer studies show similar results. Thus, in highly trained taekwondo athletes after 3 and active recreationists after 6 weeks a decrease was recorded in peak power and mean power during the Wingate test of 30 s [11, 32]. The above-mentioned studies applied the Wingate test, during which the largest part of glycolytic energy is used (56%) at a smaller part of phosphocreatine (28%) and aerobic energy (16%), so the results of these studies are explained by reduced availability of glycogen and glucose [36]. On the other hand, the performance of crossfitters did not decrease in the 400 m race, although during this distance most of the energy is provided from the glycolytic system. However, subjects lost a significant amount of body mass (–3.0 kg), which increased running economy (increased power to weight ratio) and thus it masked metabolic inefficiency, which occurs at an intensity above 70% VO_2max [16]. A slightly longer application of LCKD for 12 weeks increased peak power during the 6-second sprint (Wingate test) and peak power during the test, where pedaling was performed at maximum power and speed for 3 min, in subjects on LCKD compared with those on HCD [24]. Unlike previous studies, this study used HIIT (high-intensity interval training), strength training and a sufficient protein intake (1.9 g/kg/LBM) and despite the reduction in body weight LBM was preserved, which altogether had a positive effect on anaerobic performance. Additionally, high-intensity short-duration activities require total energy from the phosphagen system, which can further explain the improvement of the 6-s sprint in runners, as well as maintaining performance in the 100-m sprint in taekwondo athletes [32]. LCKD does not appear to have negative effects on anaerobic performance, which relies predominantly on the phosphagen energy system, whereas due to reduced glucose availability there may be a decline in those performances that rely heavily on the glycolytic system. Body mass and LBM play an important role in these performances because their optimal ratio can affect the economy of movement and the manifestation of power and speed. Likewise, the application of HIIT training during LCKD appears to play a significant role in anaerobic performance, which could be a topic of future research.

Cyclic ketogenic diet and carbohydrate supercompensation

The cyclic ketogenic diet is realized through a weekly cycle, during which an athlete adheres to a diet low in carbohydrates (10-20% of daily energy intake) for 4 to 5 days and then during the remaining 2-3 days of the cycle increases daily carbohydrate intake to 60-70% of total energy intake. During the LCKD phase the athlete can improve the body composition and maximize FFA oxidation, whereas during the carbohydrate loading phase the athlete should provide supercompensation of glycogen, which will allow high-intensity work [52]. In his review Burke (2015) found that the application of LCKD (5-10 days) followed by the procedure of CHO loading (6.8-11 g/kg carbohydrates for 1-3 days) has no negative effects on endurance, but that is not superior to the standard CHO loading procedure [3]. On the other hand, in a study of Lambert et al. (2001) the group that first applied LCKD completed the 20-km race in less time compared to the group that applied the standard procedure (29.5 ± 2.9 min vs 30.9 ± 3.4, $p < 0.05$) [18]. However, the results of this study are explained by the reduced utilization of glycogen and greater reliance on FFA. Therefore, it seems that the race intensity was not high enough, so the importance of glycogen supercompensation in that study has been questioned. In turn, Michalczyk et al. (2019) reported a decrease in anaerobic performance [25], which was restored, but not improved after the CHO loading procedure. As the intensity of exercise increases, the importance of glycogen utilization and glucose oxidation increases markedly. In a study of Havemann et al. (2006) in contrast to the standard procedure the procedure of CHO loading after LCKD resulted in a decrease in anaerobic performance [14]. It has been noted that oxidation of carbohydrates is higher with the standard CHO loading procedure [3] allowing higher work intensity, while with LCKD there is a decrease in glycogenolysis and a decrease in the active form of pyruvate dehydrogenase both during rest and submaximal and maximum intensity [37]. Therefore, in comparison to the standard CHO loading procedure the combination of LCKD with the CHO loading procedure does not provide greater effects on either aerobic or anaerobic performance.

LCKD and oxidative stress

In the case of top athletes training and competition are very intensive and lead to an increase in oxidative stress and inflammation. Based on our best knowledge, only two studies by the same authors examined the antioxidant potential of the ketogenic diet in athletes. In their work, after 3 weeks of LCKD application in taekwondo athletes a significant decrease was recorded in the oxidative marker malondialdehyde. A decrease in LDL and an increase in HDL noted in that study also indicate an increase in the antioxidant capacity of the blood. Exercise-induced oxidative stress can lead to skeletal muscle cell damage, which in turn leads to an increase in LDL, while HDL is a potent antioxidant suppressing the accumulation of oxidized lipids [33]. In another study, also conducted on taekwondo athletes, the keto diet resulted in a decrease in the cytokine called tumor necrosis factor-alpha [32]. Those authors concluded that a ketogenic diet leads to reduced oxidative stress and inflammatory response, although in those studies there was no improvement in other analyzed cytokines and oxidative markers (interleukin-6, interferon-gamma, superoxide dismutase, ROS) [32, 33]. Given that there are not enough studies on this topic, additional research is needed to examine the effects of a ketogenic diet on inflammatory response and oxidative stress after exercise in highly trained athletes.

Conclusions

Despite significant metabolic changes and increased fat oxidation the administration of a low carbohydrate ketogenic diet failed to show clear and convincing effects on endurance ability. LCKD can preserve endurance performance in sports where intensity does not exceed 65-70% VO_2max, but it is not superior to a diet high in carbohydrates. Also, negative effects on aerobic capacity can be manifested especially in women, which may be related to a lower status and transport of iron and due to the difference in fat oxidation between genders. In sports activities where the intensity exceeds 70-80% VO_2max, LCKD can have negative effects on performance, because in these sports activities the requirement for carbohydrate intake is remarkably greater. On the other hand, it seems that LCKD has no particular effects on maximum strength, power and anaerobic lactate abilities such as jumps and short sprints, because they depend on the phosphagen energy system. Further, LCKD enables the reduction of body mass and fat mass and maintenance of lean body mass, which can be useful in aesthetic sports, sports classified by body weight, as well as all other situations where the goal is to establish optimal body composition. However, compared to a diet with a high carbohydrate content, it is challenging to increase LBM and resistance training with an adequate protein intake and the minimal carbohydrate intake necessary for muscle mass preservation or one slightly exceeding that minimum. Additional research is needed to examine the impact of LCKD on inflammatory response and oxidative stress after exercise in highly trained athletes.

Conflict of interests

The author declares there was no conflict of interest.

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CASE STUDY

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The management of rotator cuff tendonitis in a dancer

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Abstract
Introduction. **Many forms of dance are associated with a high risk of injury due to the regular rehearsal of movements often with limited rest periods that may exceed normal range of motion and lower limb injuries are most prevalent.** Aim of Study. **This case study aimed to discuss the management of rotator cuff tendonitis in a dancer.** Material and Methods. **The patient was a female 24-year-old university dance student who attended a Sports Injury Clinic with a complaint of bilateral shoulder pain. The patient was reviewed by a physiotherapist who performed a subjective and objective assessment.** Results. **A diagnosis of rotator cuff tendonitis was made based upon the positive test for shoulder impingement and the reduction of these symptoms identified via a positive scapula assistance test and scapular retraction test. A positive empty can test, pain on abduction above 90° and pain on resisted abduction and tenderness were suggestive of involvement of the supraspinatus muscle.** Conclusions. **Management of rotator cuff tendonitis in dancers requires the identification of aggravating movements and the other underlying factors that can influence the development of this condition. A combination of pain relief, avoidance of aggravating activities and a gradual return to dance following a scapula stabilisation and rotator cuff strengthening programme proved successful.**

KEYWORDS: shoulder, injury, dance, supraspinatus, scapula stabilisation, ballet positions.

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Introduction

Many forms of dance are associated with short sets of explosive movements requiring balance, athleticism, and artistry [20] which require strength, speed, power, agility, cardiovascular endurance, flexibility, coordination, and balance [2]. These movements are specific to the genre of dance and can include amongst others arabesque, jeté, sauté, plié and relevé within ballet and in modern dance may include stag, compass turn and fan kick movements. Regular rehearsal of movements often with limited rest periods that may exceed normal range of motion (ROM) may increase injury risk. Most dance injuries occur in the lower limb, with overuse and foot and ankle injuries the most prevalent [2, 9, 17]. Two systematic reviews [1, 13] have highlighted that most dance genres and levels are associated with a high risk of injury. During dance the shoulder region is less frequently injured however injuries can occur due to the requirement to perform manoeuvres such as lifts or load bearing on hands. Breaking is an unstructured dance style that requires gymnastic and acrobatic movements [19] and include demanding physical activities such as spins, splits, handstands and tumbling and is associated with shoulder injuries [5]. Breaking requires 'footwork' which involves rapid steps, 'freeze' which is the sudden halting of movement and 'power move' that requires the spinning of the entire body [5]. In ballet the requirements of 4th and 5th positon may potentially increase the risk of shoulder injury. Fourth position as described by the Royal Academy of Dance (RAD) requires one arm to be raised above the head at 90° while the other arm is at 45°. Fifth position RAD requires both arms to be rounded and held above the head and therefore requires the arms to move above 90° shoulder abduction. One injury that can potentially develop from repetitive overhead movements is rotator cuff tendonitis which is an inflammation of the supraspinatus, infraspinatus, teres minor, and subscapularis tendons that compose the rotator cuff and in overhead sports can occur due to direct trauma, poor throwing mechanics or via falls on an outstretched arm [22].

Aim of Study

This case study aimed to discuss the management of rotator cuff tendonitis in a dancer.

Material and Methods

Subjective examination

The patient was a female 24-year-old university dance student who attended a Sports Injury Clinic with a complaint of bilateral shoulder pain. She was right handed and the pain was located at the anterior aspect of the right and left deltoid muscles. During consultation the patient indicated that 3 years earlier she suffered from shoulder pain at her left shoulder which had improved to some degree with osteopathy and a course of manipulation the specifics of which she could not recall. However, within the last 2 years she observed a gradual onset of worsening pain in both shoulders at the anterior deltoid region. For both shoulders there was no specific mechanism of injury however she had danced regularly using a contemporary or ballet style since the age of 8 years old. A family history of shoulder problems existed with her sister who also danced regularly having had a rotator cuff repair however her sister was unable to recall the specific details when asked by the patient. On consultation the patient reported an "ache" at rest of 2/10 on the Numerical Rating Scale (NRS) at the anterior deltoid region. Aggravating factors were identified as moving her arms above shoulder height particularly when she has to maintain a sustained position above her head for greater than 5 seconds. The ballet positons of 4th and 5th positon were problematic due to the requirement to move her arms above shoulder height. Rest and avoidance of aggravating movements were identified as easing factors. On occasions she had difficulty getting to sleep due to the pain and sometimes had to adopt pain relieving positions in bed which involved positioning of pillows under her shoulders. Her general health was good and the patient did on occasion take paracetamol for pain relief. The patient had not had any further investigation of her shoulders via X-ray or MRI. Following the subjective the physiotherapist performed an objective assessment. The participant gave their informed consent and the study was conducted in accordance with the Declaration of Helsinki and was approved the by the University Ethics Committee.

Table 1. Shoulder assessment

Active movements	ROM and pain	Passive movements	Resisted testing (Oxford scale)	Special tests
Right shoulder flexion	130°. Pain at 80° to 130° (4/10)	140°. Pain at 80° to 130° (4/10)	grade 4	acromioclavicular shear test [8]: negative
Left shoulder flexion	140°. Pain at 80° to 130° (4/10)	140°. Pain at 80° to 130° (4/10)	grade 4	scapular assistance test [15]: positive
Right shoulder abduction	125°. Pain at 80° to 125° (5/10)	145°. Pain at 80° (5/10)	grade 4	scapular retraction test [16]: positive
Left shoulder abduction	125°. Pain at 80° to 125° (5/10)	145°. Pain at 80° (5/10)	grade 4	Hawkins–Kennedy test [11]: positive
Right lateral rotation	60°, no pain	60°, no pain	grade 4	instability load and shift test [12]: negative
Left lateral rotation	50°, no pain	50°, no pain	grade 4	slap lesion, O'Briens test [18]: negative
Right medial rotation	T7, no pain	T6, no pain	grade 4	lift off test [10]: negative
Left medial rotation	T5, no pain	T5, no pain	grade 4	empty can test [14]: positive. Pain 7/10
Horizontal flexion	full ROM, no pain	full ROM, no pain	not tested	resisted abduction: positive. Pain 5/10

Note: All pain was reported using the NRS and was located at the anterior aspect of the deltoid. ROM was measured using a goniometer (Vivomed, Downpatrick, United Kingdom). Resisted testing used the Oxford Scale and movements were tested in standing and a supine position.

Results

Objective examination
On examination the right shoulder was slightly lower than the left with increased anterior rotation in comparison to the left side. Rounding of the shoulders was present. There was a normal kyphotic and lordotic curvature of the spine and no scapula winging was present. Cervical spine active and passive flexion, extension, side flexion and rotation were pain free and had full ROM. Left and right thoracic spine rotation was limited to ¾ ROM but pain free and the thoracic 5th and 6th vertebrae were stiff upon palpation. Scapulohumeral rhythm was abnormal on active shoulder flexion and abduction.

Discussion

Differential diagnosis
A provisional differential diagnosis of rotator cuff tendonitis was made based upon the positive test for shoulder impingement (Hawkins–Kennedy test) [11] and the reduction of these identified symptoms via a positive scapula assistance test [15] and scapular retraction test [16]. A positive empty can test [6], pain on abduction above 90° and pain on resisted abduction and tenderness at the supraspinatus tendon at its insertion at the greater tuberosity of the humerus were suggestive that the supraspinatus muscle was involved. All shoulder movements were rated as grade 4 (Oxford scale) suggestive of the development of a generalised weakness possibly due to the duration of symptoms and the fear of making symptoms worse through activity.

Management
The initial decision was to commence a course of physiotherapy with the aim of improving the patients' symptoms and at this stage further investigation via imaging was not considered. In rotator cuff tendonitis the tendons develop a swollen, hypercellular appearance associated with a disorganised collagen matrix and increased nerve density and vascularity which can result in proliferation and cell death [24]. Supraspinatus tendonitis can progress to a full rotator cuff tear and this has been observed at the time of surgery in patients with reoccurring tendinopathy [23]. It was reported in a systematic review that a therapy-based approach that avoids surgery is the optimal option for rotator cuff injury [7] and therefore a conservative approach was advocated initially in the case of this patient. A further systematic review and meta-analysis [21], suggested physiotherapy was effective for the treatment of subacromial impingement which was potentially an aggravating factor in the development of the injury. Therefore, the choice of physiotherapy was supported and following discussion with the patient it was clear that previous osteopathy treatment had focussed on manipulation techniques with little consideration of pain relief, avoidance of aggravating activities, scapula stabilisation and rotator cuff strengthening.

Pain relief and avoidance of aggravating activities
The first aim of management was to treat the tendonitis which could potentially be achieved via a number of options including ice treatment, avoidance of aggravating activities, the use of nonsteroidal anti-inflammatories, glyceryl trinitrate patches, electrotherapy, acupuncture and corticosteroid injection. These approaches have a varying evidence base and following discussion with the patient it was decided that the best approach initially would be ice treatment and avoidance of aggravating activities. The patient was reluctant to try any form of pharmacological approach. The patient stopped dancing completely for 2 weeks and maintained their cardiovascular fitness via regular gym based cycling 4 times per week which would not aggravate the shoulder joints and followed their normal lower limb strengthening and core stability work programme 4 times per week. The patient also commenced ice application using ice wrapped in a damp towel (15 minutes, 4 to 6 times daily). This treatment schedule was selected as it was deemed that the patient would have the time available to achieve this. Following this 2-week period they returned to dance with the instruction to avoid shoulder movements above shoulder height (90°).

Scapula stabilisation and rotator cuff strengthening
The second aim involved the correction of abnormalities that had been identified during assessment and included supraspinatus muscle weakness and inefficient scapulohumeral rhythm. The patient was provided with a series of scapular stabilisation exercises with the rationale that this would improve the performance of overhead movement based on the concept of kinetic chain and that fatigue may alter movement performance and increase injury risk. Four specific exercises were selected which have demonstrated activity in scapula stabilising muscles namely the scapular clock, low row, lawn mower and inferior glide [17]. The patient agreed to perform 3 sets of 6 reps of each exercise at least 4 times daily as they believed this was achievable and the physiotherapist believed that a joint goal setting approach was more likely to be effective than a prescriptive approach.

Following their initial assessment, the patient continued with this treatment programme and attended on two more occasions and on both occasions indicated that their pain levels had reduced to pain free movement when they attempted aggravating movements described previously. Following these reassessments, the decision was made to start progressing to movements above shoulder height via the development of closed chain exercises and further strengthening of the rotator cuff. At this point the patient was provided with exercises including isolated rotator cuff exercises and light resistance work using machines progressing to dumbbells including bench presses and pull downs. The patient was encouraged to focus on alignment, technique and joint stabilisation. One month following these sessions the patient made contact to state that they had returned to their previous dance schedule and they were encouraged to continue with their rehabilitation programme and make contact regarding any potential issues.

Other considerations

The family history of shoulder problems and rotator cuff repair described by the patient's sister may indicate that potentially this case could relate to issues with primary external impingement from structures that may encroach in the subacromial space. This can include congenital abnormality of the acromion which may present as excessively beaked, curved or hooked [3]. If the patient did not make adequate progress, then this potential cause could be considered further via referral for an x-ray.

The finding of reduced thoracic rotation and stiffness at T5/6 could potentially relate to the reduced ROM at both shoulders based on a concept of regional interdependence and may also have contributed to the development of the injury. If the patient did not make sufficient progress, then treatment of the thoracic spine could be considered via a manual therapy approach which has previously been advocated to reduce shoulder impingement symptoms [4]. However, as the evidence base for manual therapy is variable and potentially increases reliance on the physiotherapist from the patient it was decided that encouraging thoracic rotations and arm opening exercises would be advocated initially and would potentially aid restoration of a normal kinetic chain without the need to resort to manual therapy techniques.

Conclusions

Although lower limb injuries are more prevalent in dancers the requirement for overhead movements particularly in 5th position, partner lifting and weight-bearing through the hands can lead to the development of shoulder injuries. In breaking, the use of handstands and tumbling and power movements can also increase the risk of shoulder injury [5]. Management of rotator cuff tendonitis in dancers requires the identification of aggravating movements and the other underlying factors that can influence the development of this condition. In this patient a combination of pain relief, avoidance of aggravating activities and a gradual return to dance following a scapula stabilisation and rotator cuff strengthening programme proved successful.

Conflict of Interests

The author declares there was no conflict of interest.

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The effect of Covid-19 pandemic on healthy lifestyle behaviors and quality of life in Turkey

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Abstract
Introduction. It is very important to understand the potential for change in healthy lifestyle behaviors and quality of life of individuals before and during the COVID-19 pandemic. Aim of Study. The aim of this study was to examine changes in healthy lifestyle behaviors and quality of life in individuals living in Turkey before and during the COVID-19 pandemic from March to May 2020. Material and Methods. A total of 921 individuals were selected by convenience and snowball sampling in Turkey. The data of the study were collected using an online questionnaire. The questionnaire consisted of four parts, the first part comprised questions determining socio-demographic characteristics, the second part was the International Physical Activity Questionnaire (IPAQ) to determine the level of physical activity, the third part was a self-administered questionnaire which was developed by Sakamaki et al. (2005) as an eating habits questionnaire [23], while the last part was the Visual Analog Scale to measure the quality of life of respondents. Results. The average age of the participants was 29.38 ± 9.16 years, 57.2% were women, 61.6% worked and 53% fell in the professional jobs category. It was found that the participants' body mass index (BMI) increased 50.3% during the curfew period in the beginning of the COVID-19 pandemic ($p < 0.05$). According to IPAQ results, physical activity levels of the participants decreased statistically during the pandemic ($p < 0.5$). Considering the variables evaluating changes in participants' dietary habits, there was a statistically significant increase in regular breakfast preparation and snack consumption during the day ($p < 0.05$). Almost half of the participants (46%) reported that their quality of life had deteriorated during the pandemic. Conclusions. Consequently, when trying to prevent the COVID-19 infection or any epidemic in the short term, it is recommended not to neglect its effects on the quality of life and healthy lifestyle behaviors of the general population in the long term.

KEYWORDS: quality of life, physical activity, nutrition, healthy behaviors, COVID-19.

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Introduction

A pandemic is an epidemic of an infectious disease that has spread across a large region, for instance several continents or worldwide, affecting a substantial number of people and leading to multiple deaths [3]. The World Health Organization (WHO) on March 11, 2020 has declared the coronavirus (COVID-19) outbreak a global pandemic [31]. As of March 18, 2021, WHO statistics showed that 2,664,386 people had died from COVID-19, while over 120,383,919 infections had been confirmed [30]. The common goal of all countries since the early days of 2020 has been to take action to contain the infection until the vaccine is found and it is available for everyone globally.

As a result of the physical and social distance measures applied since March 11, 2020, when the first case was reported in Turkey, millions of people were confined to live within a limited space. In addition, the fact that leisure and entertainment venues (restaurants, cafes, shopping malls, pools, sports halls) were closed until June 1, 2020 imposed changes in people's lifestyle habits. Presumably, this dramatic change in lifestyle through immobility (hospitalization and bed rest), physical inactivity due to curfew, is seen as another adverse limitation for the health and quality of life both for infected people and the general population [28].

Prolonged staying home may lead to increased sedentary behaviors such as sitting, lying down, playing video games, watching television, using mobile devices and decreased regular physical activity, resulting in lower energy expenditure and consequently increased risk and potential deterioration of chronic health conditions [1]. It is estimated that because of the social distance measures, the eating (dietary) habits of individuals who spend most of their time at home have been changed significantly.

Healthy lifestyle is described as health-promoting behaviors, not smoking, good nutritional practices and adequate physical activity [12]. During the COVID-19 pandemic individuals' responsibility to support the immune system has been stated as choosing a healthy lifestyle, eating a diet rich in fruits and vegetables, exercising in their spare time, trying to maintain a healthy body weight and sleeping for sufficient time [16]. In addition to the above, avoidance of smoking and alcohol and minimization of stress are recommended [15]. Although social distancing reduces the risk of COVID-19 infection [4], it is estimated that isolation, quarantine and staying home for a long time together with the "pandemic fear" [17] create a negative burden on mental health [5], increase sedentary behaviors [14], decrease physical activity [2, 14, 20] all constitute a risk factor for chronic diseases and negatively affect the quality of life as a whole.

Quality of life is a broadly understood concept that is intricately influenced by an individual's physical health, psychological condition, personal beliefs, social relationships and relationships with remarkable characteristics of their environment. The WHO points out that 60% of the quality of life of individuals is provided by their healthy lifestyle behaviours [29]. While the fight against COVID-19 continues in many countries worldwide the encroachment of animal habitats by humans and the resumption of rapid intercontinental transportation increase the belief that we will face new pandemics in the near future [10]. As a result it suggests that physical and social distance measures will become permanent in our lives.

Initiatives to ensure that individuals practice healthy lifestyle behaviors despite these measures will strengthen their immune systems and fight COVID-19, as well as reduce serious threats of inactivity, thereby supporting the overall quality of life for the general public. For this reason, it is very important to understand the potential for change to promote healthy lifestyle behaviors such as physical activity, adequate nutrition, non-smoking, limitation of alcohol consumption, good sleep and quality of life in individuals before and during the COVID-19 pandemic. The main assumption of the study was that people's healthy lifestyle habits and therefore their quality of life had changed negatively. In this regard, the aim of this study was to investigate changes in healthy lifestyle behaviors and quality of life in individuals living in Turkey before and during the first wave of the COVID-19 pandemic.

Material and Methods

Study participants

The study was conducted with individuals aged 18--64 years living in Turkey. In the national level studies regarding the representation of the country's population it is stated that a sample size of 1000 people provides statistically significant evaluations with a ±3% standard error [13]. In the study convenience sampling (researchers reach out on their social networks) and snowball sampling methods (by asking the participants to share the survey with their own social networks) were used to reach the target sample within a short period of time. The data of the study were collected between 11 May and 25 May (15 days) 2020. In the study 921 participants completed the survey (±3.23% standard error). Ethical approval for the study was obtained from the Şırnak University Ethics Committee on 27.05.2020, number 74546226-020/.

Data collection tools

The data were collected via an online survey. Access to the survey forms was provided by personally sharing the QR code and posting the survey on various social media platforms. It takes 10-15 minutes to complete the survey.

The survey questionnaire form consists of three parts. The first part comprises questions concerning demographic and socio-economic information (age, gender, marital status, education, employment status and economic status) and health status of individuals (self-rated health, presence of chronic disease, height and weight for BMI). The second part of the survey questionnaire consists of five indicators considering the "Healthy People 2020" [8] goals in order to assess healthy lifestyle behaviors of the participants. These indicators include physical activity, healthy diet, smoking, alcohol consumption and a consistent sleep pattern. The International Physical Activity Questionnaires (IPAQ) Short Form was used to establish the participants' physical activity levels. This survey was developed by Craig et al. [7] to determine physical activity levels of the participants between the ages of 15-65. The Turkish validity and reliability study of the questionnaire was conducted by Ozturk [19]. The level of physical activity was classified as physically inactive (<600 MET-min/week), low physical activity (600-3000 MET-min/week) and sufficient/adequate physical activity health promoting (>3000 MET-min/week) [7]. Dietary, smoking and alcohol habits of the participants were assessed using an 11-question survey form previously applied in several studies [6, 23], which does not require adaptation according to region. In this form dietary habits, namely breakfast habits, consumption of snacks, consumption of vegetables and fruit as well as consumption of fried dishes were examined together. Sleep habits of the participants were determined by asking the question „On average, how many hours do you sleep on a normal day".

The third part of the survey assessed the participants' quality of life using the Visual Analog Scale ("On the following scale below, we ask you to rate your quality of life on a scale of 0 to 10") [24]. Because it is impossible to conduct a pre-pandemic survey, the second and third parts of the survey were answered twice with subjective estimation of the state before and during the pandemic measures.

Data analysis

Statistical analysis of the data was conducted using descriptive statistics and hypothesis tests in the SPSS 22.0 IBM, USA package program. The suitability of quantitative variables to normal distribution was tested with the Kolmogorov–Smirnov test. To statistically test the difference in healthy lifestyle behaviors and quality of life before and during the pandemic the Dependent Sample t-test was applied for quantitative variables and McNemar's test for categorical variables. The statistical significance level in the analyses was accepted as $p < 0.05$.

Results

The distribution of 921 people participating in the study according to their socio-demographic characteristics is shown in Table 1. The age of participants ranged from 18 to 64 years at the mean of 29.38 ± 9.16 years and 60.5% of the participants were in the age group of 18-29 years. A total of 57.2% of the participants were women, and 68.4% of the participants were single. Socio-economic status indicators of the participants showed that 91.2% of them have higher education, 61.6% are employed, 53% are in the category of professional jobs and 28.7% rate their economic status as good. While 106 people (11.5%) who participated in the study reported having a chronic disease, 59.3% of the participants rated their general health as good. During the COVID-19 pandemic period, BMI was found to increase in 50.3% of the participants.

Table 1. The distribution of participants according to selected characteristics

	Frequency (n)	Percentage (%)
Gender		
women	527	57.2
men	394	42.8
Age		
18-29	557	60.5
30-49	331	35.9
50-64	33	3.6
Level of education		
high school or below	81	8.8
bachelor degree	840	91.2
Marital status		
single	630	68.4
married	291	31.6
Profession		
qualified	488	53.0
don't require qualification	103	11.2
not working	330	35.8
Employment status		
yes	567	61.6
no	354	38.4
Economic situation		
poor	657	71.3
good	264	28.7
Chronic disease		
yes	106	11.5
no	815	88.5

Self-rated health		
good	546	59.3
poor	375	40.7
Change in BMI*		
stable	194	21.1
increased	463	50.3
decreased	264	28.7
Change in quality of life[a]		
stable	385	41.8
increased	111	12.1
decreased	424	46.0

[a] BMI values before and during the pandemic were calculated based on the participants' statements of height, pre-pandemic weight and weight during the pandemic. According to the difference between the two values, the change in BMI was calculated. Change in quality of life was calculated in the same way.

Table 2 shows changes in quantitative variables (BMI, sleep – hours, sedentary time – hours, IPAQ-MET value) before and during the pandemic, while Table 3 shows changes in qualitative variables.

As can be seen in Table 2, the BMI of the participants showed a statistically significant increase of approximately 1% during the pandemic. When evaluated together with the change in BMI categories in Table 1 and Table 3, it is clear that the BMI for a majority of the participants increased during the pandemic and more participants moved to the above normal weight category. Secondly, it was found that participants' average sleep and sedentary time increased statistically significantly during the pandemic. When examining the MET-minute/week scores used to analyze the participants' IPAQ data, it was found that the participants' MET-minute/week scores decreased statistically significantly on average by 39% during the pandemic.

Table 2. Quantitative lifestyle changes before and during the COVID-19 pandemic

	Pre-Pandemic	During Pandemic	t	p
	Mean ± SD	Mean ± SD		
BMI	23.26 ± 4.00	23.47 ± 4.01	–2.038	0.000*
Sleep (hours)	7.33 ± 1.13	8.61 ± 2.10	–18.288	0.000*
Sedentary time (hours)	3.64 ± 4.41	8.44 ± 4.61	–14.697	0.000*
IPAQ-MET	3.122 ± 3.652	1.897 ± 3.119	9.657	0.000*

* $p < 0.05$

Table 3 shows that the participants' BMI increased statistically significantly during the pandemic and more participants moved into to the above normal BMI category ($p < 0.05$). Considering the variables evaluating changes in the participants' dietary habits we found that

Table 3. Qualitative lifestyle changes before and during the COVID-19 pandemic

	Pre-Pandemic		During Pandemic		p
	Frequency (n)	Percentage (%)	Frequency (n)	Percentage (%)	
BMI					
underweight (<18.5)	97	10.5	83	9.0	
normal (18.5-24.9)	557	60.5	553	60.0	0.003*
overweight (≥25.0)	267	29.0	285	30.9	
Eating regularly					
regular	588	63.8	575	62.4	0.443
irregular	333	36.2	346	37.6	
Healthy breakfast					
daily	513	55.7	585	63.5	
four-day week	163	17.7	123	13.4	0.041*
two-day week	121	13.1	60	6.5	
rarely	124	13.5	153	16.6	

Snack					
daily	300	32.6	303	32.9	0.002*
four-day week	171	18.6	223	24.2	
two-day week	173	18.8	162	17.6	
rarely	277	30.1	233	25.3	
Green, red and yellow vegetables					
daily	262	28.4	262	28.4	0.560
four-day week	365	39.6	358	38.9	
two-day week	209	22.7	204	22.1	
rarely	85	9.2	97	10.5	
Fruit					
daily	280	30.4	315	34.2	0.466
four-day week	277	30.1	240	26.1	
two-day week	197	21.4	183	19.9	
rarely	167	18.1	183	19.9	
Frying					
daily	36	3.9	38	4.1	0.776
four-day week	158	17.2	174	18.9	
two-day week	363	39.4	320	34.7	
rarely	364	39.5	389	42.2	
Alcohol					
never	427	46.4	536	58.2	0.000*
2-3 times a week	131	14.2	99	10.7	
rarely	363	39.4	286	31.1	
Smoking					
yes	340	36.9	290	31.5	0.000*
no	581	63.1	631	68.5	
Physical activity					
inactive	263	28.6	543	59	0.000*
low	280	30.4	217	23.6	
adequate	378	41	161	17.5	

* $p < 0.05$

there is a statistically significant increase in regular breakfast preparation and snack consumption during the day ($p < 0.05$). A statistically significant decrease was recorded in alcohol consumption and smoking habits of the participants during the pandemic ($p < 0.05$). It may be concluded that most participants preferred to abstain from alcohol and smoking. When examining changes in the physical activity level of the participants it was found that physical activity decreased statistically significantly during the pandemic ($p < 0.5$).

Almost a half of the participants (46%) reported that their quality of life deteriorated during the pandemic, as

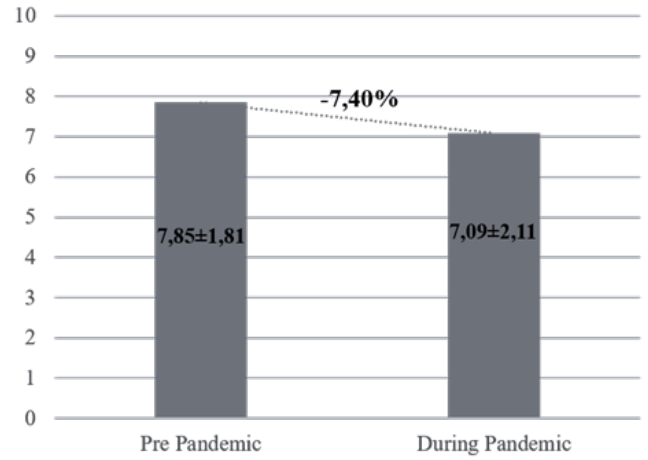

Figure 1. The quality of life of participants before and during the COVID-19 pandemic

seen in Table 1. It was determined that the average scores of the Visual Analog Scale, which shows the quality of life ratings of the participants, decreased statistically significantly during the pandemic with an average of 7.40% ($t = 12.040$; $p < 0.05$), as seen in Figure 1.

Discussion

The aim of this study was to determine the effect of the COVID-19 pandemic on healthy lifestyle behaviors and quality of life among individuals living in Turkey. The most important results of the study can be summarized as follows. Firstly, the physical activity levels of individuals decreased during the pandemic. Secondly, it can be stated that there was a positive change in breakfast habits and a negative change in snack consumption. Finally, the quality of life of individuals deteriorated.

When physical activity indicators of people participating in the study were examined, a statistically significant decrease was found in the proportion of those who were sufficiently physically active before the pandemic and 59% of them were not active during this period. In parallel with the decrease in physical activity, it was observed that the average daily sedentary time increased by 131%. Similarly, many previous studies confirmed that physical activity decreased while sedentary time increased during the pandemic period in Canada [25], in the USA [14] and in multinational studies [2, 20]. During the pandemic period the closure of sports halls and swimming pools and the imposition of a long weekend curfew in Turkey prevented physical activities outdoors.

When changes in the participants' lifestyle are examined in terms of healthy nutrition a positive change in breakfast habits and a negative change in snack consumption may be observed. Similarly, studies of Di Renzo et al. on 3,533 people in Italy [9] and Sidor and Rzymski on 1,097 people in Poland [25] showed that eating habits during the COVID-19 period changed. In investigations conducted by Ruiz-Roso et al. in Spain [22] and Górnicka et al. in Poland [11] snack consumption was also found to increase. However, insufficient consumption of vegetables and fruits by the participants was also valid for the pre-pandemic period and supports the findings of the Turkish Nutrition and Health Survey [26]. During the pandemic the transition of many workplaces to working from home or to short-term work may have improved the regular breakfast habit, but it was observed that staying at home for a long time increases the consumption of snacks due to stress.

It was found that 50% of the participants had a statistically significant increase in BMI. The negative effects of the pandemic period on BMI were also shown in studies by Ruiz-Roso et al. [22] and Sidor and Rzymski [25]. As a result of the negative effect on physical activity and diet it was found that the participants were not able to maintain their ideal body weight during the pandemic period.

When examining the average daily sleep times of individuals as an indicator of their healthy lifestyle behaviors, it was found that individuals who participated in the study had the ideal amount of sleep time before and during the pandemic when their sleep time increased on average by 17%. Although sleep time was considered as a variable in some studies focusing on lifestyle changes with the COVID 19 pandemic, it indicates parallel results with the findings of the study [11]. On the other hand, there are almost no studies in Turkey that take the "sleep" variable into account as a healthy lifestyle habit.

In addition to the proven negative effect of smoking on health, experts have stated that it is a serious risk factor for the patient's condition to deteriorate and be severe in the case of COVID-19 [27]. It was accepted as an important change that 50 people who participated in the study stopped smoking during this period. Similarly, it was found that alcohol use by the participants decreased statistically significantly during that period. This could be explained with the lockdown or home confinement and limited access to public spaces [2, 20].

Finally, it was found that people's quality of life as measured by the visual analog scale decreased statistically significantly by about 7.40% with the pandemic. In comprehensive studies by Ammar et al. [2] and Repišti et al. [21], it was found that the quality of life deteriorated during the pandemic period.

It would be correct to evaluate the results of the research with some limitations. Since the convenience sampling method was used in this study, generalizing the results to the whole of Turkey may lead to incorrect conclusions. The questionnaire was designed as an online survey and the sample population in the study was limited to people who had an online access. The accuracy of the data collected in the study is based on the assumed correct and sincere responses of the participants in the questionnaires.

Conclusions

To our knowledge, this study is the first in Turkey on changes in healthy lifestyle behaviors and quality of life as short-term consequences of the COVID-19 pandemic period. The main findings of the study reveal the development of interventions in two important aspects. First, the measures and precautions taken during the pandemic period should be implemented with supportive interventions that prevent the spread of COVID-19 while mitigating negative health outcomes in the general population. One of the most important lessons to be learned during the COVID-19 pandemic period is to encourage people to stay at home, while instructing them to stay active at home and eat healthy. Secondly, even if it is not possible to continue some habits due to legal restrictions during the pandemic period (e.g. daily swimming is no longer possible, because swimming pools are closed), a healthy lifestyle will strengthen the immune system while fighting COVID-19. Additionally, it should not be ignored that it supports efforts to continue a normal lifestyle in various ways despite the limitations, which should be encouraged in all circumstances. For example, involvement in physical activity while maintaining social distancing [18] needs to be encouraged. Considering the insufficiency of physical activity and the prevalence of obesity in Turkey, it is not an unwarranted concern that COVID-19 may cause multiple negative health consequences in the long term.

Conflict of Interests

The author declares there was no conflict of interest.

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Does different repetition duration modify the post-activation performance enhancement effects?

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Abstract

Introduction. **The post-activation performance enhancement (PAPE) is a phenomenon characterized by an acute enhancement of maximal voluntary strength, power or speed and have been used to increase acute performance in explosive activities. However, the effects of different repetition duration during the conditioning activities in PAPE have not been established yet.** Aim of Study. **The present study aimed to compare two different repetition duration a) Conditioning Activity Concentric (CAConc) (i.e., 1-sec-eccentric/3-sec-concentric), and b) Conditioning Activity Eccentric (CAEcce) (i.e., 3-sec-eccentric/1-sec-concentric) on subsequent countermovement jump performance.** Material and Methods. **Fourteen males recreationally trained participated this study. Participants alternately performed CAConc and CAEcce protocols in the leg press 45º and, after a 4-min recovery interval, performed three countermovement jumps. A 72-hour recovery interval was adopted between the protocols.** Results. **No significant difference in mean height and relative power of the countermovement jump among baseline and both protocols, as well as between CAConc and CAEcce ($p > 0.05$). However, percentage increases in mean height and relative power were observed between baseline and CAEcce (mean height: 1.36%/relative power: 2.25%), as well as between CAConc and CAEcce (mean height: 1.91%/relative power: 1.22%).** Conclusions. **CAEcce did not produce significant increases in the countermovement jump than CAConc, although greater percentage increases were observed for the CAEcce.**

KEYWORDS: **countermovement jump, post-activation potentiation, concentric action, eccentric action, conditioning activity.**

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Introduction

The ability to develop power output in the lower limbs is considered a key factor for success in several sporting tasks such as sprint events [25], being decisive in jumping, kicking and sprint actions in team sports [31], as well as attack and defense in combat sports [17]. For this reason coaches and sports scientists are constantly looking for new approaches and verify their applicability to improve this ability [21]. The power output of the lower limbs may be enhanced through different warming strategies based on a high-intensity conditioning activity using half-squat [4, 8]. The increase in performance observed after a high-intensity conditioning activity is known as post-activation performance enhancement (PAPE) [14].

This phenomenon might be associated with the post-activation potentiation residue in its earliest stages after a conditioning activity, in addition to several other mechanisms, such as an increased temperature and muscle activation, as well as the shortening velocity triggered by the water content in the muscle fiber [6, 14, 37].

Boullosa [8] recently highlighted that several moderating factors such as type and exercise load, recovery interval and timing should be considered in order to better individualize and implement PAPE protocols. Furthermore, other factors such as the manipulation of eccentric muscle action have been shown to be effective in inducing PAPE when compared to the control [5] and traditional resistance training groups [4] during countermovement jump. To perform the eccentric action, these studies generally use flywheel devices combined with the half-squat [4, 5, 16]. Nevertheless, these devices are costly, making the application of this warming strategy unfeasible for most athletes. Alternatively, Wilk et al. [37] investigated the effects of different eccentric durations (medium: 2-sec and slow: 6-sec) on power output and bar velocity during three sets of the bench press exercise. Those authors concluded that PAPE effects were observed for both times of movement [37]. However, the effects of concentric duration on PAPE have not yet been clarified. Although the effects of repetition duration on resistance training have already been reported in terms of muscle strength [15], they are still limited with regard to PAPE [37], making it difficult to prescribe this variable during previous conditioning activity. Furthermore, Krzysztofik et al. [22] stated that little attention has been paid to the potential effect of PAPE on training volume. To achieve the desired training volume, performance of a certain number of repetitions (REP) per set, per exercise and per session can significantly affect adaptive changes induced by resistance training [24]. However, the duration of a single REP is not always the same, being dependent on the movement time used. In this way, in addition to the number of REP performed in a set or in an whole training session, the time under tension (TUT) is considered an important variable to describe the training volume [24]. According to Wilk et al. [34, 38], TUT during resistance exercise is a more accurate and reliable indicator of the training volume compared to the number of REP performed. To date, only two studies have examined the effect of PAPE on the volume of upper body resistance training, but only one of them considered TUT. Sevilmiş and Atalağ [33] observed a significantly increased REP number and TUT during a single set of bench press exercise performed until voluntary failure at 65% 1RM after a conditioning activity with eccentric actions at 120% 1RM compared to the control conditions. Moreover, Alves et al. [2] also reported an improvement in the training volume assessed by the total lifted load (REP × × load) and the maximum number of REP performed after a conditioning activity.

Thus, the present study aimed to compare two different repetition durations: a) Conditioning Activity Concentric (CAConc) (i.e., 1-sec-eccentric/3-sec-concentric), and b) Conditioning Activity Eccentric (CAEcce) (i.e., 3-sec-eccentric/1-sec-conconcentric) on subsequent countermovement jump performance. Based on a previous study [37], the authors' hypothesized that the CAEcce protocol would induce greater improvements in the countermovement jump performance than the CAConc protocol.

Material and Methods

Experimental design

A randomized, cross-over study design was adopted to verify the effects of the CAConc and CAEcce protocols on the subsequent countermovement jump (CMJ) performance. Each participant visited the laboratory four times separated by a 72-hour interval (Figure 1). During the first visit participants were familiarized with the CMJ and the experimental protocols. The familiarization with CMJ consisted of five sets of three jumps, while the experimental protocols consisted of one set of ten repetitions at 50% 1RM estimated. During the second visit participants were subjected to anthropometric assessments, CMJ baseline, and one-repetition maximum test (1RM) in the leg press 45° (LP45). In the third and fourth experimental sessions

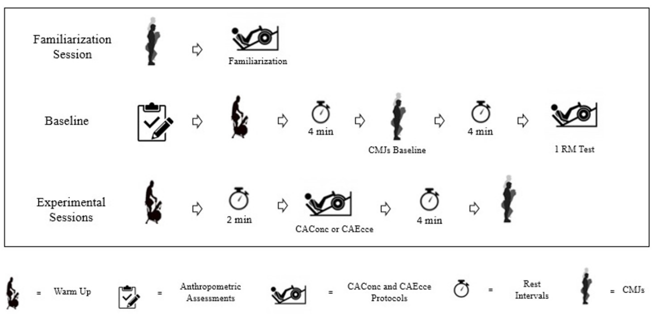

Figure 1. Experimental design

Note: CAConc – Conditioning Activity Concentric; CAEcce – Conditioning Activity Eccentric; CMJs – countermovement jumps; 1RM – one repetition maximum after a 5-min warm-up on the ergometer cycle at a self-selected intensity, participants performed the CAConc or CAEcce protocols and after the next 4-min rest interval they were subjected to performance assessment using CMJ tests.

Participants

Fourteen recreationally-trained males participated in this study (mean ± SD: age 20.6 ± 1.8 years; height 1.74 ± ± 6.1 m; body mass 74.6 ± 7.3 kg; body fat 10.2 ± 5.2 %; 1RM 331.0 ± 56.8 kg). To be volunteers in the study, participants needed to have a minimum experience of six months in resistance training with a weekly frequency of at least three times a week. All participants who had any health problems and/or bone, joint and muscular disorders that could affect their ability to complete the study protocol were previously excluded. Furthermore, all participants were instructed not to perform strenuous exercise and not to take caffeine or any nutritional supplement before testing. Before the study participants signed a consent form previously approved by the local human research ethics committee (CAAE: 59466616.5.0000.5148) in accordance with the Declaration of Helsinki.

Anthropometric assessments

A scale with a stadiometer was used to measure the height and body mass of the participants (110 FF, Welmy®, Santa Bárbara d'Oeste, Brazil). Body fat was determined using a B-mode ultrasound system (Bodymetrix pro System, Intelametrix®, Livermore, USA).

One repetition maximum testing

The 1RM testing was assessed using an LP45 inclined press (Physicus®, Auriflama, Brazil). For the 1RM testing participants attended the laboratory at the same time as the experimental sessions and performed a 5-min warm-up on a cycle ergometer at a self-selected intensity. Subsequently, participants performed 15, 10, and 5 repetitions using loads corresponding to 20, 50, and 70% of their self-reported 1RM. Thereafter, the first testing load was adjusted to an estimated 80% 1RM and increased by 2.5 to 5 kg in each trial until failure, using a 5-min recovery interval after each successful trial following Wilk et al. [35], who used this protocol during the bench press. Between 1 and 3 repetitions were used for a maximum of 5 trials until participants were able to perform only one repetition maximum. The LP45 was started with the knees semi-extended and then participants performed the eccentric phase of the movement until their knees were at approximately 90° of flexion. Afterwards participants performed the concentric phase and returned to the initial phase of semi-extension of the knees. The technique of performing the exercise was verified by a single experienced evaluator and feedback was provided to the participant throughout the trials. During the testing movement speed (cadence) was maintained at (2/0/1/0), i.e. a 2-s eccentric phase, 0-s (no break in the transition phase), a 1-s concentric phase and 0-s (no rest before the next repetition) [34] using a digital metronome (DM90, Seiko®, Tokyo, Japan).

Conditioning activity protocols

Both protocols (CAConc and CAEcce) were performed in the LP45. Before starting each protocol participants performed a standard warm-up on a cycle ergometer (5-min at a fixed speed of 60 rpm with a load corresponding to 50 Watts). Next, participants performed 3 sets of 5 repetitions on the LP45 using loads adjusted to 70% 1RM [37] with two different repetition durations: 1) CAConc: (3/0/1/0), i.e. a 1-s eccentric phase, 0-s (no break in the transition phase), a 3-s concentric phase, and 0-s (no rest before the next repetition), and 2) CAEcce: (1/0/3/0), i.e. a 3-s eccentric phase, 0-s (no break in the transition phase), a 1-s concentric phase, and 0-s (no rest before the next repetition) [34]. The recovery interval between the protocols with the respective conditioning activity and the countermovement jumps was 4 minutes according to Hughes et al. [20], who used this protocol during the back squat.

Countermovement jump

To measure the countermovement jump performance (height jump and relative power) in both protocols participants performed CMJ testing [7] using a contact platform (Cefise®, Nova Odessa, Brazil) interconnected to a software (version 1.0; Jump System). Participants performed three CMJs with a 15-sec rest interval between attempts. Coefficients of variation (CV) ranged from 0.6 to 1.4%. To exclude the influence of arm-swing, participants were instructed to keep their hands on their hips during attempts. The mean for the three CMJs was calculated and used to determine the performance [10]. The Intraclass Correlation Coefficients (ICCs) for the day-to-day reproducibility of the dependent performance measures were recorded at ICCs ≥0.95.

Statistical analysis

The data are presented as means ± standard deviations. The normality of the data was assessed using the Shapiro–Wilk test. A one-way ANOVA with repeated measures and Bonferroni's post-hoc were used to compare the baseline and the protocols (i.e. CAConc and CAEcce). The effect size was assessed using the following criteria: ≤0.40, 0.41-0.80, and >0.80, being interpreted as small, moderate and large, respectively, according to Cohen [11]. As statistical evidence, a significance level (α) of 5% was adopted using the SPSS statistical software (version 25.0; IBM Corp, Armonk, NY).

Results

The 1RM, loads and density were the same for both variants and are shown in Table 1.

Table 1. Training load variables

Variables	Mean
1RM	331.0 kg
Load	231.7 kg
Density	0.06

Note: 1RM – one repetition maximum

No significant difference was found in mean height of the countermovement jump ($p > 0.05$) between CAConc (36.6 ± 5.9 cm), CAEcce (37.4 ± 6.3 cm) and the baseline (36.8 ± 5.7 cm) (Figure 2). Moreover, a trivial effect size was found between the baseline, CAConc and CAEcce in the mean height of the countermovement jump (Table 2).

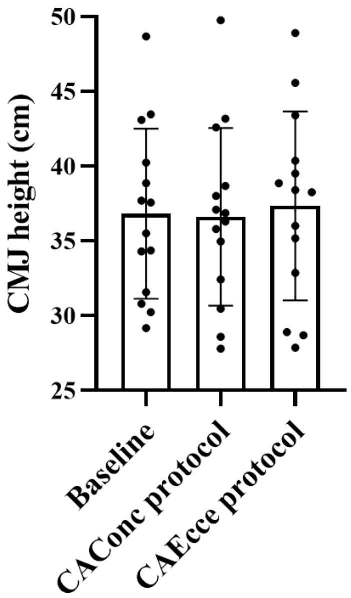

Figure 2. Comparison of mean height of the countermovement jump among baseline and conditioning activities protocols

Note: CAConc – Conditioning Activity Concentric; CAEcce – Conditioning Activity Eccentric; CMJ – countermovement jump

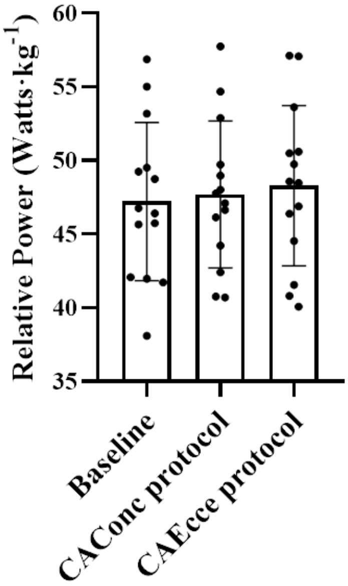

Figure 3. Comparison of relative power of the countermovement jump among baseline and conditioning activities protocols

Note: CAConc – Conditioning Activity Concentric; CAEcce – Conditioning Activity Eccentric

Table 2. Δ%, effect size (d), and p values in mean height of the countermovement jump for baseline, CAConc, and CAEcce

Protocols	Δ%	Cohen's (d)	(p) values
CAConc – baseline	–0.54%	–0.03	0.563
CAEcce – baseline	1.36%	0.08	0.347
CAEcce – CAConc	1.91%	0.11	0.679

Note: CAConc – Conditioning Activity Concentric; CAEcce – Conditioning Activity Eccentric

Table 3. Δ%, effect size (d), and p values in relative power of the countermovement jump among baseline, CAConc, and CAEcce

Protocols	Δ%	Cohen's (d)	(p) values
CAConc – baseline	1.02%	0.07	0.458
CAEcce – baseline	2.25%	0.18	0.287
CAEcce – CAConc	1.22%	0.11	0.699

Note: CAConc – Conditioning Activity Concentric; CAEcce – Conditioning Activity Eccentric

No significant difference was found in mean relative power of the countermovement jump ($p > 0.05$) between CAConc (47.6 ± 5.0 watts · kg^{-1}), CAEcce (48.3 ± ± 5.6 watts · kg^{-1}) and the baseline (47.2 ± 5.4 watts · kg^{-1}) (Figure 3). Furthermore, a trivial effect size was found between the baseline, CAConc and CAEcce in relative power of the countermovement jump (Table 3).

Discussion

The main findings of the present study refuted the authors' initial hypothesis, indicating that there was no significant difference in mean height and relative power of the countermovement jump between the baseline and both protocols, as well as between CAConc and CAEcce. On the other hand, percentage increases in mean height and relative power were observed between the baseline and CAEcce, as well as between CAConc and CAEcce.

Eccentric exercises have been used as a conditioning activity to enhance performance in the countermovement jump, presenting opposite results [4, 5, 16, 20, 37]. Beato et al. [5] verified that 3 sets of 6 repetitions in the half-squat performed on a flywheel device improved countermovement jump performance (i.e. height, peak power, impulse and peak force) compared to traditional warm-up (i.e. cycle ergometer) in male athletes. However, when the same protocol using a flywheel device was compared to the traditional weightlifting half-squat, the results showed no difference between the protocols in the countermovement jump performance [4]. Using a simple protocol to accentuate the eccentric load through 6 drop jumps without the propulsive phase and with the standardized box height at 60-cm, Hughes et al. [20] found significant improvements in the countermovement performance compared to a traditional half-squat protocol. These results are further supported by findings of Wilk et al. [35], who showed that different eccentric durations yielded a PAPE effect during the bench press. Although we did not use an essentially eccentric protocol in the present study, in percentage terms the authors' results indicated that the repetition duration with an emphasis on the eccentric phase showed a greater percentage PAPE effect compared to the emphasis on the concentric phase.

Physiologically, it seems that one of the main mechanisms for post-activation potentiation may be associated with increases in the recruitment of fast-twitch motor units [19]. Ojasto and Häkkinen [29] showed greater increases in blood lactate concentrations when higher eccentric loads were used. This progressive increase in blood lactate concentrations as a function of the magnitude of the eccentric load provides strong evidence for the recruitment of fast glycolytic muscle fibers [20]. In parallel, the subsequent performance might be enhanced as exercise with an eccentric overload is introduced into the conditioning activities, possibly due to the muscular stretching provided by the eccentric actions [20], which might increase synchronization of the motor units leading to an improved power output [28]. These hypotheses may be partially justified by the close relationship found between eccentric peak force and countermovement jump height [9]. Furthermore, it has been reported that the production of eccentric force is dependent on the number of active actin-myosin cross-bridges [18]. Therefore, any post-activation potentiation mechanism such as phosphorylation of myosin light chains that allows their heads to move closer to the actin binding sites [1], making it more sensitive to Ca^{+2} availability [37], may increase the rate of cross-bridge formation [27] and improve the contraction in movements involving the stretch-shortening cycle [13]. Although the CAEcce protocol caused only percentage changes in mean height and relative power of the countermovement jump compared to the baseline and the CAConc protocol (Table 2, Table 3), minor changes in the jump performance may represent a real improvement and be sensitive to post-activation potentiation mechanisms. In this line, if we consider that the coefficient of variation for the countermovement jump of professional athletes is around 1.6% [3] and take into account that this individual characteristic presents a low smallest worthwhile change [12], the percentage increases found in the authors' study might at least be considered important. In addition, the authors' results also suggest that the repetition duration with an emphasis on the concentric phase seems to attenuate performance in the subsequent countermovement jump. These results may be potentially important for prescribing repetition duration during a conditioning activity, where coaches should prioritize a slower eccentric phase and a faster concentric phase, although further studies on the repetition duration in conditioning activity are still needed to confirm this claim.

Wilk et al. [36] showed that a different distribution of movement tempo during a set of resistance exercises has a significant impact on power performance of the upper limbs. The use of slow repetitions at the beginning of a set, with longer TUT, may be effective in stimulating muscle strength and hypertrophy. However, the possibility of using a slow movement tempo, particularly in the concentric action, is limited by external load. Therefore, the use of a slow movement tempo causes a decrease in external load, which may reduce strength gains following long-term resistance training. Previous studies indicated that heavier loads produce greater strength gains than lighter loads, although the movement speed could be faster [32]. In this case, athletes could consider using a slow movement tempo in the first repetition only in the eccentric action, using a fast or explosive tempo in the concentric phase of movement (e.g. 6/0/X/0). For power development the training with the intention of moving the load explosively is believed to be optimal for power adaptations, irrespective of the contraction type, load or actual movement speed of the exercises used. Therefore, the use of slow repetition will reduce the movement speed, which will have a significant negative effect on acute power output and, as a consequence, may potentially limit the possibilities of power development. The use of different movement tempo distributions during a set may be useful, mainly during complex resistance training [39]. The slow movement tempo in the first repetition (which will cause an increase in muscle activation and lengthen TUT) and an explosive movement in the next repetitions (which will increase concentric speed) should be optimal both for hypertrophy development and power output. It is also possible to use an inverse tempo distribution to those presented in this study, where fast repetitions will be performed at the beginning of the set and slow repetitions at the end of the set. Such complex resistance training may be an effective alternative compared with traditional resistance protocols, especially when the time to perform specific resistance training goals is limited.

For the emphasis on the eccentric phase during the conditioning activity to significantly enhance subsequent performance, it may be necessary to apply heavier loads in the strength exercise (i.e. >70% 1RM), since essentially eccentric training requires supramaximal training loads in PAPE protocols [30]. However, several factors such as conditioning activity, training status, volume and intensity may interfere in the balance between fatigue and post-activation potentiation and influence the disparities found in the results of the studies [26]. Krzysztofik et al. [23] evaluated changes in power output and bar velocity in the bench press throw (BPT) following the bench press as a conditioning activity with concentric only (CONONLY) and eccentric only (ECCONLY) actions. Participants performed 2 sets of 2 repetitions using the bench press as a conditioning activity at 90% 1RM ECCONLY, 90% 1RM CONONLY, 110% 1RM ECCONLY, or 130% 1RM ECCONLY. The BPT was performed to assess changes in peak power, mean power and peak velocity, mean velocity before and after conditioning activity. This study demonstrated that the conditioning activity with ECCONLY movement at 110% and 130% 1RM significantly increased power output and bar velocity during the BPT, which may improve performance in explosive sports activities. Furthermore, the application of partial movement sequences during resistance training sessions may introduce new, additional stages of periodization in the development of power output, which opens opportunities for modification of strength training programs, particularly in elite strength-trained athletes. Partial movement sequences (ECCONLY) may be effective in short-term power output development, but only when the load used in the conditioning activity exceeds 100% 1RM. Partial movements with loads below 1RM may be insufficient to elicit the PAPE effect in strength-trained individuals. However, it should be stressed that these results and training suggestions apply primarily to elite athletes with a high level of muscular strength and extensive experience in resistance training at the use of loads above 100% 1RM.

As a practical application, power sports athletes could use a slower eccentric phase in combination with a more explosive concentric phase during their conditioning activity. This combination could potentially be important to improve explosive performance, specifically when the conditioning activity is performed with submaximal lifting loads.

Conclusions

The present study demonstrated that repetition duration with an emphasis on eccentric action during the conditioning activity did not significantly increase the mean height and relative power of the countermovement jump, although there were percentage increases compared to the emphasis on concentric action. Furthermore, the emphasis on concentric action seems to decrease performance during the countermovement jump.

Conflict of Interests

The author declares there was no conflict of interest.

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Effects of low, medium and high intensity walking on sleep quality and psychological well-being of the elderly women with cognitive impaired

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Abstract
Introduction. The rapid growth of aging population, in recent years is the result of a process known as the demographic transition. Cognitive disorders such as dementia and delirium, common problems in older adults, are influenced by deteriorating quality and quantity of sleep and psychological well-being and depression. Aim of Study. The purpose of the present research was to investigate the effectiveness of low, medium and high-intensity walking in the quality of sleep and psychological well-being of elderly women suffering from cognitive impairment. Material and Methods. A pre-test and post-test quasi-experimental research design was selected for the study. The sample consisted of 80 elderly women in the age range of 60-75 years who were randomized into four experimental groups. Exercise intensity was evaluated and controlled by pedometers. In the pre-test and post-test stages, all subjects completed the Pittsburg Sleep Quality Index and the psychological well-being scale. The data analysis was conducted using inferential statistical tests such as repeated measures ANOVA and Bonferroni post-hoc tests. Results. In the pre-test stage (prior to the intervention), the results showed no significant differences between the control and experimental groups in terms of well-being, sleep quality and their subcomponents (P > 0.05). In the post-test stage (after the intervention), the results indicated significant differences between control and experimental groups in terms of well-being and sleep quality (P < 0.05). The Bonferroni post-hoc test showed that low, moderate, and high-intensity group had higher scores in sleep quality and well-being compared to the control group (P < 0.05). Conclusions. The results showed that low, moderate, and high-intensity walking has a positive and significant effect on well-being and sleep quality of women with cognitive impairments. Thus, based on these findings, walking is recommended as a useful and health promoting method to improve sleep quality and the well-being of women with cognitive impairments.

KEYWORDS: walking, well-being, elderly women, pedometer, sleep quality.

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Introduction

The rapid growth of the aging population, as opposed to the general population, in recent years has been the result of a process known as demographic transition. According to the World Health Organization (WHO), the number of people over 60 years of age, which was 590 million in 2000, is expected to surpass 1.2 billion in 2025. The vast majority of these people (70%) live in the developing countries [2]. According to the demographic forecasts, if the current trend of population growth persists, the population of people over 60 years of age (9.2% of the total population) would have surpassed the total population of children under 5 years of age (8.5% of the total population) by 2020 [4, 6]. Lack of autonomy and independence, as well as inability to perform daily activities, lead to the deterioration and loss of cognitive function in elderly people. The cognitive status depends on the systematic functioning of different brain systems. The aging process undermines the performance of those systems, which triggers cognitive problems. The severity of this disorder varies greatly and may include a wide range of elderly people. Cognitive disorders such as dementia and delirium, being common problems in older adults, are influenced by the deteriorating quality and quantity of sleep and psychological well-being as well as depression [3, 30].

Research shows that the increasing prevalence of cognitive impairments in the elderly gives rise to another old age-related problem, sleep disturbances, which has a significant impact on mental and physical problems of the elderly. Sleeping is a key element in the circadian rhythm, which is associated with physical and mental rejuvenation. Epidemiological studies suggest that more than 57% of the elderly report sleeping problems and only 12% are satisfied with their sleep [2, 9]. More than 40% of older adults report poor sleep quality [7]. Although the time spent in bed increases as we age, the real sleep duration decreases. Moreover, the length of deep sleep stages (stages 3 and 4 of non-REM sleep), as the main factor in sleep quality, is reduced. At the age of 70 the delta phase of sleep makes up less than 10% of the total sleep duration, as opposed to 25-50% in adolescents and young adults. However, despite the importance of this issue, scant attention has been paid to sleep research. Insomnia is a common sleep disorder in older adults. Studies show that sleep disorders in elderly people may lead to depression, falls, cognitive disorders, concentration problems, irritability, poor quality of life, dementia, fatigue, mood instability, anxiety and poor mental health [16].

A review of literature suggests that most elderly people take hypnotic drugs to deal with problems associated with the perceived sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep sufficiency and poor daily performance [12, 31]. An important point that needs to be stressed here is that hypnotic agents are effective for short-term use and should not be prescribed for long periods of time [18]. Thus, it seems that the best way to improve sleep quality is to identify a method to reduce adverse physical and mental symptoms in the elderly.

Non-pharmacological treatments take effect more slowly than hypnotic drugs do, but they are more durable and display fewer side effects such as addiction. Gerontologists have introduced regular physical activity as a method increasingly recognized as a way of initiating and maintaining good sleep by providing calmness and increasing core body temperature. It is presumed that sleep and physical activity are separate behaviors controlled by separate physiological mechanisms, but there is ample evidence that demonstrate a clinical relationship between sleep and physical activity [4, 6]. Based on some studies, decreased sleep duration in older adults can be associated with reduced physical activity and prolonged inactivity. Research results reported significant improvement in the quality and quantity of sleep in older adults after moderate-volume aerobic exercise (e.g. walking) [23, 24].

King et al. determined the effect of a 16-week aerobic exercise program including walking and running on the quality and quantity of sleep in older adults, reporting that this exercise increased sleep duration in participants by 42 min. However, their results did not reflect a dramatic change in the quality of sleep [15]. In another study, Oda reported significant improvement in sleep quality of the subjects after 6-month exercise, but they found no significant changes in stage 3 of non-REM sleep [4]. Similarly, Oda did not observe a significant alteration in the quality and quantity of sleep in the elderly following water exercise [22]. The quality of sleep is a major factor in promoting physical and cognitive functioning of elderly people, but it is impossible to effectively address problems of elderly people without focusing on different aspects of their mental health. Therefore, researchers and practitioners seek to improve all aspects of mental health in different age groups, considering psychological well-being as a major aspect of the elderly life.

As people age, the level of their psychological well-being decreases due to their diminishing independence and physical abilities. Researchers argue that a factor that may affect psychological well-being in the elderly is connected with exercise and physical activity [29]. Findings of two other studies have shown that participation in aerobic exercise programs improves psychological well-being in the elderly [5, 25]. Bustamante et al. reported that older adults with higher levels of physical activity have more favorable levels of psychological well-being [8]. In a systematic review, Shams et al. reported that only limited studies have firmly concluded that physical activity exerts a permanent positive effect on the psychological well-being of the elderly. Therefore, they suggested that a regular program of low to moderate-volume physical activity may have a greater effect on improving people's psychological functioning as opposed to a vigorous aerobic activity or non-aerobic activity. Despite inconsistent findings concerning the effects of varying intensities of physical activity on sleep quality and psychological well-being of the elderly, scientific evidence shows that the ability and motivation to engage in aerobic activities such as cycling, swimming, and running, decreases with age [31]. Despite the obvious physiological benefits of exercise and physical activity for the public, most people assume that regular daily physical activity with low, moderate, and high volume - determined based on the metabolic and physiological parameters of workout volume (e.g. lactate threshold, maximal oxygen consumption, etc.) – is difficult and unusual [20]. In other words, continuous regulation of every session of physical activity based on the percentage of maximum heart rate, heart rate reserve, baseline heart rate, maximum oxygen consumption and lactate threshold, as well as the mathematical assessment of activity volume is difficult for ordinary people in general and for the elderly in particular. It is while the evaluation of a physical activity program including its duration, volume and number of sessions per week is a major concern of experts and researchers [14, 33]. It seems that a convenient way to adjust the volume of an exercise program that is easy to understand is to apply the customary and valid style of counting steps, which has received growing attention in Japan and the European countries as a way of measuring the volume of physical activity. Additionally, studies show that as we age, we develop a tendency to prefer walking as a common form of aerobic activity, mainly because it is practicable in various conditions and environments. Walking is an exhilarating form of physical activity that is generally accepted by the public and commonly practiced during leisure time and daily activities and its execution is driven by pleasure, promotion of performance of bodily systems, and rehabilitation.

Therefore, the present study attempted to determine the volume level of physical activity in the elderly based on step counts per day using valid and reliable pedometer devices. The purpose of pedometers is twofold. Firstly, it can be easily used to determine the volume of physical activity in older adults. Secondly, they do not need to be worried about determining the volume of their daily physical activities, as this goal could be achieved with little costs. Since most interventional studies have only considered the effectiveness of one volume level of aerobic exercise on sleep quality and psychological well-being and they provided inconsistent results regarding the effects of physical activity on sleep quality and psychological well-being of the elderly, this study was conducted to compare the effectiveness of low, moderate, and high levels of physical activity for sleep quality and psychological well-being of the elderly with cognitive impairments.

Material and Methods

This was a quasi-experimental study with pre-test – post-test design. The population included elderly women attending the municipality neighborhood houses, senior centers, parks, gardens and recreational centers at district 1 of Tehran. After a general invitation for elderly women to participate in the study, 200 women willing to do so were selected using a convenience sampling method. Then, based on the exclusion and inclusion criteria 80 elderly females aged 60-75 were selected and randomized into four groups: three experimental groups with low, moderate, and high levels of physical activity and a control inactive group. The exclusion criteria included a history of asthma, respiratory and cardiovascular disease, disabilities or use of mobility aid devices such as crutches and wheelchairs, a history of cerebrovascular accidents, serious skull damage, a history of anesthesia, motor disorders, and unwillingness to continue the study. The main inclusion criterion was a basic level of physical activity. All of the above criteria and factors were controlled using the demographic questionnaire (Figure 1).

The main study instruments included a demographic questionnaire, the Mini–Mental State Examination (MMSE), psychological well-being questionnaire, the Pittsburgh sleep quality index and a pedometer. The validity of the demographic questionnaire was confirmed by experts. MMSE developed by Folstein in 1975 is one of the tools commonly used to assess the cognitive status. The questionnaire consists of several dimensions including orientation, registration, memory, attention, calculation, recent memory, language and visuospatial abilities. Each person is awarded a score of 1 to 30 with scores greater than 25 indicating lack of cognitive impairment, 20-25 indicating possible cognitive damage, and less than 20 denoting a definitive detection of cognitive disorders. The validity and reliability of the questionnaires were measured several times. The validity of the instrument used to evaluate the cognitive status of the elderly has already been assessed in psychiatry textbooks [10]. The internal consistency of the questionnaire was measured based on Cronbach's alpha (0.81) and its sensitivity and specificity in the cut-off point of 22 were 90% and 93.5%, respectively.

The psychological well-being questionnaire is an 84-item scale with 6 components of environmental mastery, independence, positive relations with others, personal growth, purposefulness and self-acceptance.

Each component consists of 14 items that are scored on a 6-point Likert scale (from "strongly disagree" to "strongly agree"). Ryff et al. reported a test–retest reliability of 0.82 for the questionnaire and 0.70 to 0.78 for its components. The test–retest reliability of the Iranian version of the questionnaire was also measured at 0.82. The PSQI is a questionnaire that measures self-reported sleep habits over the past 4 weeks. It is a global measure with 7 components: perceived sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, sleep sufficiency and the use of sleep medication. The score for each component is in the range of 0 to 3, with high scores indicating poorer sleep quality. A score of 5 (i.e. poor sleep) yielded a diagnostic sensitivity and specificity of 89.6% and 86.5%, respectively. The internal consistency of the scale was confirmed with Cronbach's alpha (α = 0.83), and test–retest reliability of 0.85 in this study [2]. In their research on seniors aged 60 and above in Iran, Ahmadi et al. reported a reliability of 0.87 using the Kappa coefficient [2]. A portable pedometer (OMRONHJ_113) with less than 1.5% error was used to measure daily steps.

This small device using a sensitive accelerometer measures the number of an individual's steps and the distance a person travels. Ultimately, based on the initial information (such as weight and the length of steps) given to the device, it measures one's status of physical activity and the amount of calories burned. McNamara et al. measured the concurrent validity of the pedometer with an accelerometer and its convergent validity with

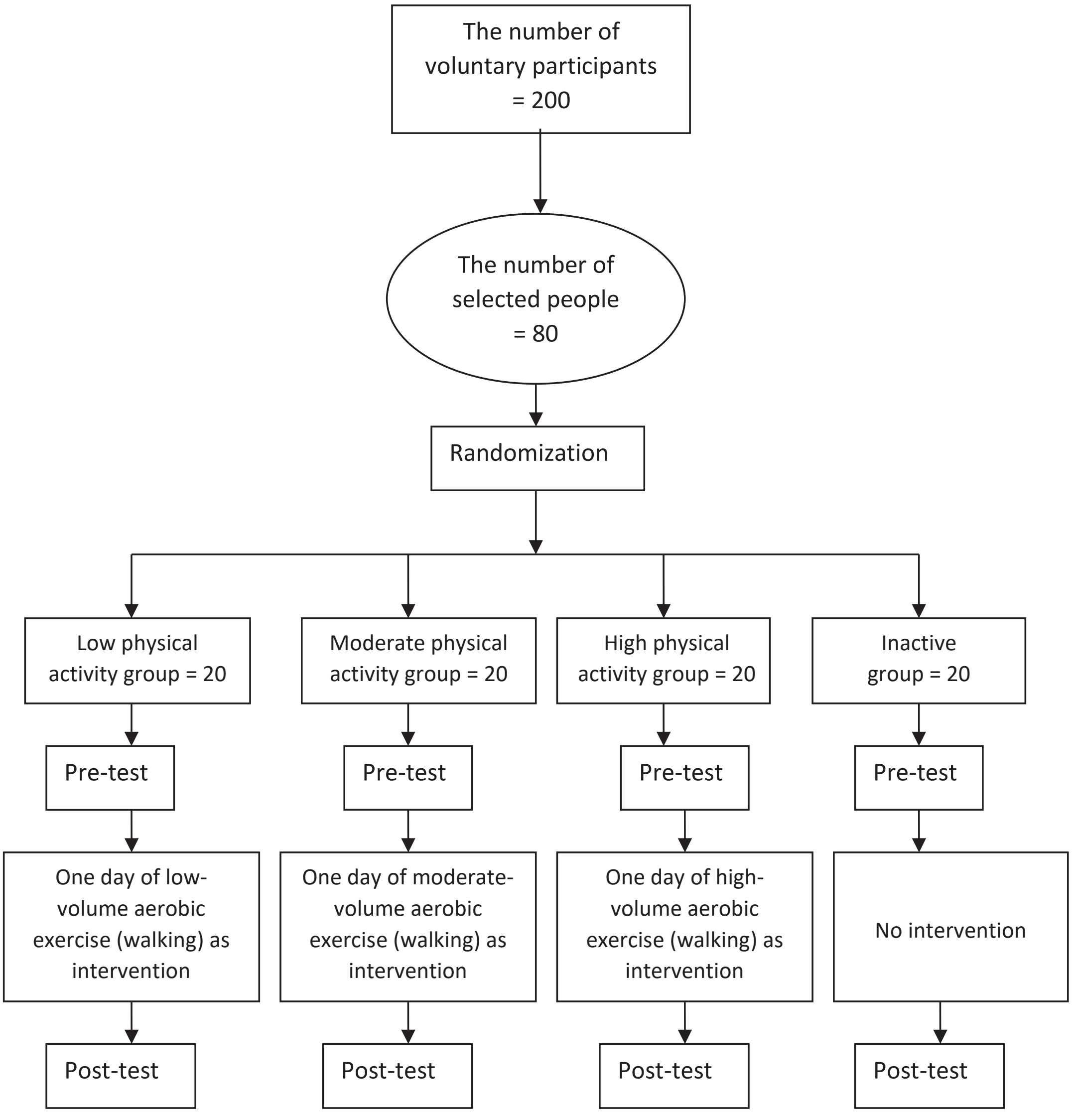

Figure 1. Data sampling and research method

a heartbeat meter using the Pearson coefficient (0.55--0.99) [19]. These researchers reported a convergent reliability correlation coefficient of 0.88 for the pedometer at the maximum oxygen consumption. McNamara et al. in a study entitled "The correlation between the results obtained from a pedometer and the international physical activity questionnaire (IPAQ)" reported that the pedometer had acceptable validity and reliability [19]. Before the study the cognitive performance of the subjects was assessed using the MMSE test and the elderly women with cognitive impairment were included in the present study. After screening the participants based on the study criteria, they filled out the pre-test questionnaires (which concerned low, moderate, and high volume physical activity) including the Pittsburgh sleep quality index (PSQI) and the psychological well-being scale. Afterwards, the subjects learned how to use the pedometer and record its data. The participants were the elderly with low levels of physical activity. In other words, their activity level at the baseline (the two-week period, during which their level of physical activity was determined) was less than the physical activity level recommended by the WHO for a healthy life (less than 5,000 steps per day). Based on these inclusion criteria all the elderly participating in the study were identical in terms of the basic level of physical activity.

To determine the basic level of physical activity in the subjects the elderly were requested to wear the device on their waist all day long for two weeks [33]. They were also requested to record the number of their daily steps in the specific form. After selecting 80 elderly people with low levels of physical activity, they were randomized into four groups (each group consisting of 20 elderly women). According to Gilson et al. and Tudor-Locke et al., more than 12,500 steps per day indicate a very high level of physical activity, between 10,000-12,499 steps indicate a high level of physical activity, between 7,500-9999 steps denote a moderate level of physical activity, between 5,000-7,499 steps denote a low level of physical activity and less than 5,000 steps per day is considered as inactivity [11, 32]. The four levels of physical activity (high, moderate, low, and non-active) were selected as the intervention levels for the elderly in the four groups. After the completion of the pre-intervention phase the subjects entered the intervention phase. Exercise protocols included 6 weeks (3 sessions per week and a total of 18 sessions) of physical activity in the form of walking and counting steps using a pedometer (step counters). In the experimental groups the volume of physical activity (the number of steps taken per hour) was measured with the use of pedometers worn around the waist of the subjects at 5-8 p.m.

A day after the completion of the study protocols participants in the four groups filled out the post-test questionnaires including the psychological well-being scale and the Pittsburgh sleep quality index. The data were analyzed using ANOVA, repeated measure ANOVA and the Bonferroni post-hoc test. The results of the Shapiro–Wilk test showed normal distribution of the data ($P > 0.05$). Levene's test also confirmed the homogeneity of the variable variance in the four groups ($P > 0.05$). The results of Levene's test exhibited homogeneity between the variances in the experimental groups ($P > 0.05$). The mean sleep quality of older adults with cognitive impairment in the experimental groups with low, moderate, and high levels of physical activity in the pre-test and the post-test phases is presented in Table 1.

Table 1. Mean of sleep quality in pre-test and post-test phases

Variable	Low volume of physical activity		Moderate volume of physical activity		High volume of physical activity		Inactive	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Sleep quality	12.1	5.67	10.90	5.37	5.37	11.75	11.20	10.75

The repeated measure ANOVA in the four experimental groups during the pre-test and post-test phases showed that the test stages (pre-test – post-test) had a significant effect and the mean sleep quality of subjects in the post-test phase was significantly higher than that of the pre-test phase ($P < 0.05$). The group main effect was also significant, so that the subjects in the inactive group had poorer sleep quality than those in the other groups ($P < 0.05$). The interactive effect of the inactive group at different tests was also significant (Table 2).

Table 2. Results of repeated measure ANOVA to compare sleep quality in pre- and post-test stages

	Sum of squares	df	Mean squares	F	P-value
Main effect of test stage	726.75	1 and 76	726.750	147.47	0.001
Mean effect of group	79.68	3 and 76	26.56	13.44	0.001
Interactive effect	215.21	3 and 76	71.74	14.55	0.001

The results of the Bonferroni post-hoc tests to evaluate post-intervention paired differences showed that the subjects (elderly women) with cognitive problems in the high, moderate and low level activity groups reported higher sleep quality than those in the inactive group (Figure 2).

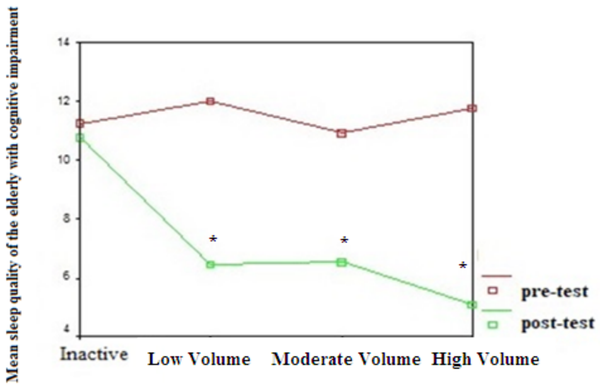

Figure 2. A comparison of sleep quality in pre-test and post-test phases

The pre- and post-test mean scores of psychological well-being for the older adults in the intervention groups (high, moderate, and low physical activity volume) and the inactive group are presented in Table 3.

The results of repeated measure ANOVA showed that the main effect of the test stages (pre-test – post-test) was significant and the mean score of post-intervention psychological well-being was significantly higher than that of the pre-intervention stage ($P < 0.05$). The main group effect was also significant so that the subjects in the inactive group had lower psychological well-being than the other groups ($P < 0.05$). The interactive effect of the group at test stages was significant (Table 4).

The results of paired comparison test using Bonferroni post-hoc test showed that after the intervention, the subjects in high and medium level activity groups had better psychological well-being than the other two groups (Figure 3).

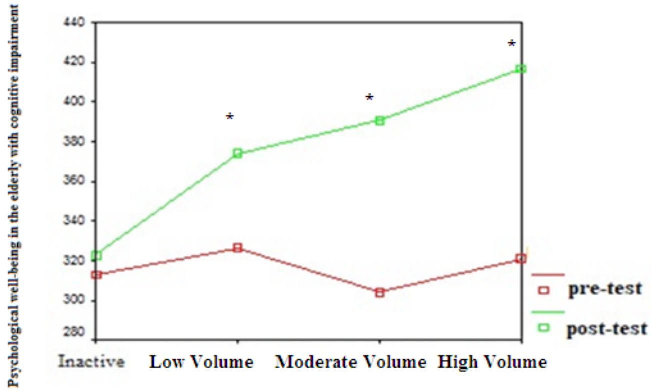

Figure 3. Comparison of psychological well-being before and after the intervention

Discussion

This study aimed to determine the effects of aerobic walking exercise with high, moderate and low level volumes on the psychological well-being and sleep quality in older adults with cognitive impairment. The results showed that different levels of walking activity have varying effects on cognitive disorders and sleep quality in older adults. Hence, the subjects in the high volume physical activity group experienced greater sleep quality than those in the inactive group. Also the subjects in the moderate volume physical activity group showed better sleep quality than those in the low volume physical activity and the inactive groups. Studies reported that aerobic activity plays an important role

Table 3. Scores of psychological well-being among older adults

Variable	Low volume of physical activity		Moderate volume of physical activity		High volume of physical activity		Inactive	
	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Psychological well-being	326.50	374.20	304.01	390.60	321.35	416.30	312.90	322.80

Table 4. The result of repeated measures ANOVA to compare the psychological well-being of the subjects in the four groups at pre-test and post-test

	Sum of square	df	Mean square	F	P-value
Main effect of test stage	143041.60	1 and 76	120.08	143041.60	0.001
Mean effect of group	26651.56	3 and 76	8883.85	12.84	0.001
Interactive effect	45851.95	3 and 76	15283.98	12.92	0.001

in the autonomic control of the cardiovascular system. It can improve the control of parasympathetic nerves and decreases the control of sympathetic nerves in the cardiovascular system. Therefore, it induces a positive effect on the physiological mechanisms of sleep, such as improved sleep quality and duration of sleep [26].

A variety of theories and models related to the mechanism underlying the effect of aerobic activity on the quality of sleep have been proposed. According to the thermo-regulating theory, during slow wave sleep the core body temperature drops and the number of awakenings rises [1, 13]. Aerobic activity can also increase melatonin secretion. Melatonin is a hormone secreted from the pineal gland, a small gland in the cerebrum that helps the body to regulate the sleep-wake cycle. Melatonin can result in elevated core body temperature and therefore increase duration of sleep [12, 26]. The restoration theory of sleep suggests that anabolic activities (reactions that provoke growth and development) are heightened during sleep and catabolic activities increase during the day.

In order to restore and maintain the balance of energy and maintain appropriate body conditions, the amount of energy depleted due to bodily activities during daytime should be restored at rest. For this reason the body needs to sleep [24]. According to the restoration theory of sleep, sleeping is essential for revitalizing and restoring the physiological processes that keep the body and mind healthy [3, 24]. Akbari Kamrani et al. also developed the body energy maintenance theory, according to which aerobic activity may produce desirable changes in the circadian rhythm and increase the level of adenosine. Improved physical fitness in the elderly through exercise and physical activity may increase delta wave during non-REM stages 3 and 4, and therefore enhance the quality of sleep [2, 4].

Wang et al. (2014) reported that maintaining mobility and physical activity diminishes daytime drowsiness and improves sleep quality in the elderly. Sustained performance of daily activities such as bathing or eating is more effective in improving sleep quality than other important activities such as shopping, using public transport and making doctor appointments. The disparity of results with those of our study may be due to the differences in the study population, age range, divergent study design, cultural differences, type of aerobic exercise and its duration and volume as well as different tools and instruments. Our results also manifested significant differences between psychological well-being of the elderly women in the four groups. The scores for the psychological well-being of the subjects in high and moderate volume physical activity groups were significantly higher than those in the low volume physical activity and inactive groups [35].

In general, it could be concluded that human well-being relies on dealing with daily problems and experiences gained through these encounters. These experiences can affect one's thoughts and attitudes regarding various aspects of life. The results of this study showed that the adoption of an active lifestyle as a new experience in old age could have a positive effect on the psychological well-being of the elderly. Reid et al. argued that the effect of moderate and high levels of physical activity on improving psychological well-being in the elderly could be attributed to the nature of sport in terms of its attractiveness, as well as the social effects of exercise on people's cultures, which could be crucial to forging positive relationships with others [26].

Physical activity and sports also curb anti-social and ageist behaviors. Researchers also stated that physical activity in the elderly diminishes activity limitations, fosters independence, improves the performance of tasks and promotes a happy and successful life, which leads to the increased quality of life, and psychological well-being. Therefore, it can be construed that old people with low levels of psychological well-being can partially alleviate internal personality conflicts and achieve enhanced mental and social growth by engaging in physical activities as a favorable environmental experience. As shown by the results of other studies and our research, physical activity, sports and entertainment leads to a happy and satisfying life for senior citizens. Entertainment and recreational activities strengthen their self-confidence, while with improved physical, psychological and social dimensions the elderly can save themselves from the vicious circle of aging [26, 33, 34, 35].

A review of 25 studies suggested that moderate exercise is effective in alleviating tension, depression, confusion and psychological well-being, whereas high volume physical activity is less effective in this regard [31]. In turn, Wang et al. reported that a session of aerobic exercise with 60% maximal aerobic power on a stationary bicycle causes fatigue and reduces vitality and psychological well-being. Researchers reported that a 30-min session of aerobic activity with moderate volume, as opposed to high volume exercise, can further improve components of psychological well-being in people with severe clinical depression. Research shows that mental, psychological and physical fatigue may explain the ineffectiveness of high volume physical activity in improving mental psychological well-being in older adults [35].

Conclusions

The results of the present study suggested that walking and an active lifestyle leads to a significant improvement in psychological well-being and sleep quality in elderly women with cognitive disorders. Therefore, adopting an active lifestyle can be a desirable alternative to sleep and sedative medications prescribed in conventional treatments, which can pave the way for enhancing the quality of life and active participation of older adults in the community.

Given the rising elderly population, the physical, mental and social welfare of the elderly should be given priority in order to promote their health and prevent or reduce old age-related diseases. These results of this study can have implications for practitioners in the fields of medicine, psychology, sport psychology and other social disciplines as well as the staff of elderly health care centers.

One of the limitations of this study resulted from its restriction to the female Iranian elderly and a lack of review of studies of non-Iranian elderly and male elderly. Other limitations include failure to control other variables such as the level of education, personality and working background of the elderly women, which can influence the results. Future research is recommended to control these variables.

Conflict of Interests

The authors declare no conflict of interest.

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Table 1. Descriptive statistics and comparative analysis of maximal oxygen uptake (VO_2max in ml/kg·min^{-1}) between genotypes of the I/D *UCP2* gene polymorphism

UCP2	DD					ID					II				
Sex	*N*	$\bar{x}$	*SD*	*Min*	*Max*	*N*	$\bar{x}$	*SD*	*Min*	*Max*	*N*	$\bar{x}$	*SD*	*Min*	*Max*
F	42	45.65	*6.14*	32.30	59.00	36	45.66	*7.18*	30.60	59.80	7	45.07	*7.60*	35.00	54.80
M	72	54.01[a]	*6.20*	40.30	79.00	70	55.60	*7.32*	42.30	76.80	12	59.07[a]	*9.04*	49.70	74.90

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