

Contemporary Approaches to Physiological Adaptations after Taper Workouts

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ABSTRACT

This study was conducted to systematically compile and synthesize the studies about taper training in literature and in the most current form, to reveal the physiological changes caused by taper trainings. Qualitative research methods were used for in-depth study and interpretation of the studies on taper applications published between 1985-2020. Document analysis was used as data collection method and the obtained data were analyzed by content analysis method. Taper training is a complex training method that facilitates the systematic reduction of the training load and the attainment of the physiological harmony. Before the major competitions the reductions in load, density, volume or frequency of the training in order to achieve optimal performance are made which is called the taper. The aim of taper training is to reduce fatigue and increase physiological adaptation and performance in athletes through intensive training. Since each sport branch has different physiological demands, taper trainings are applied differently in individual and team sports. The effects of these practices may vary in athletes in different branches. In the literature studies, some increases were found in the blood volume and red blood cells values, muscular glycogen deposits, some enzymes, blood lactate and VO₂ max. values and the movement economies of athletes. However, in some studies, some decreases were found in the levels of the respiratory threshold, creatine kinase in the blood and the values of the submaximal ventilation, the diastolic and systolic blood pressures of the athletes.

Keywords: Taper training, athlete, performance improvement, physiological changes

INTRODUCTION

The main goal for trainers working with elite athletes is to offer a systematic and controlled training program so that the athletes can demonstrate their maximum performance in important competitions. It is very important to include taper practices in such a program (1, 2, 3). The practice of taper strategies in elite sports is determined by daily interaction with athletes, largely based on the trainers' own observations and experiences (4, 5).

Today, taper training, which is used to improve performance in sports, can be defined in different ways. Taper is characterized by decreases in training capacity and / or intensity to ensure adequate recovery in athletes (6). Before important competitions, the reduction in training load, intensity, capacity or frequency in order to improve athletes' performances is called taper (3, 7, 8). According to another definition, taper is a recovery technique used before competitions to get rid of the stress on the organism after an intensive training (9). In other words, taper training is to reduce the training intensity in order to provide physical and physiological recovery in various training periods to provide maximum competitive performance before the competition (10, 11). Taper is also expressed as the last step in the training program practices in the last few weeks before the competition (8, 11).

The term taper was first introduced in 1947 by Carlile and Cotton. In a study conducted on swimmers, Carlile and Cotton observed significant improvements in the athletes' performances when swimmers made a reduction in training intensity starting 3 weeks before the target competition after 2-3 months of hard training. They stated that these performance improvements were the result of taper practices. Taper training have continued to be practiced differently by both trainers and athletes in different periods. Fredric (1983) used the term "Zapotec Effect" to emphasize

the importance of resting before the competition. Czech distance runner Emil Zapotek fell ill while training very hard for the European Games in Busseli in 1950, had to stay in the hospital for 2 weeks, and although he left the hospital just 2 days before the 10,000 meter race and could not train enough, he won the race without difficulty. Another example is that Dave Bedford was injured before the 10.000 m race in 1973 and he participated in the 10.000 m race by keeping his training at a minimum level for a few months and broke the world record in the competition (12). Until 30 years ago, there was a widespread belief that athletes should concentrate their training and do intense training before the most important races of the season. Trainers used to think that as a result of such training, the athletes would reach their maximum performance. Studies on this subject have shown that this is not the case at all. It was determined that when athletes did extensive and vigorous training for peak performance before the competition, they were tired and did not show the expected success in races (12).

How the taper practices will affect different motor performance outputs stands out as an important issue that needs to be investigated. In this context, it will be more important to try to explain physiologically and morphologically how the taper practices affects the motor performance outcomes. Because, identifying or determining possible mechanisms that might explain why the motor performance output changes will provide valuable contributions to the literature.

The aim of this study is to examine the physiological changes caused by taper training on the organism and to investigate the effects of taper training on the athletes' performances in the studies conducted in the literature.

METHOD

In this study, qualitative research methods are used for in-depth analysis and interpretation of studies about taper published between 1985-2020. Document analysis is used as the data collection method in the study, and the data obtained is analyzed by content analysis method.

The following chronological order is pursued in the review of the relevant documents in the literature; accessing documents, checking authenticity, understanding documents, analyzing data and using data. In the process of accessing documents, written and internet resources related to the subject were scanned and classified chronologically. Then, by checking the originality of the sources, the documents were analyzed in a specific system and in comparison with each other. Finally, all the data obtained were combined into a meaningful whole and the writing stage was started.

Taper Training and Muscle Energy Use: Exercise's energy cost is known as an important determinant of performance (13). If an athlete is consistently doing high-capacity training, the athlete's muscle energy stores can be expected to decline chronically. In this case, a reduction in the training volume during taper can be tolerated by an appropriate diet program. Initial muscle glycogen levels are known to have no effect on short term high intensity performance. In fact, performance decreases due to overtraining and performance rise after tapering may occur independently from muscle glycogen levels during short-term activities (14, 15).

However, initial glycogen levels can affect performance during repetitive high-intensity training, as well as 60 min or more endurance training. Large muscle glycogen stores are essential for tapering practices for athletes. Measurements related to muscle glycogen utilization, such as lactate and aerobic enzymes, are less affected by taper. The increase in muscle glycogen stores with taper training accelerates recovery and decreases fatigue. In this case, it contributes to the improvement of the performance of athletes (16, 17, 18).

In a study conducted on endurance athletes and by Skovgaard et. al. (2017), the athletes did an 18 day taper and then the athletes ran 10 km. As a result of that study, it was reported that there was no change in the glycogen stores of the athletes' before and after 10 km run (19).

Physiological Changes in Organism as a Result of Taper

1. Cardiovascular Changes

Considering the relevant literature, it has been seen that taper practices have an important effect on the development of the cardiovascular and respiratory systems of athletes. Taper causes some functional and structural changes in the cardiovascular and respiratory systems of athletes, even if it is practiced for a short time.

1.1. Maximal Oxygen Consumption (VO₂ max):

Maximal oxygen consumption (VO₂ max) is defined as the highest amount of oxygen taken up, carried and used by the body during vigorous exercise. It is accepted as the most important criterion of cardiorespiratory endurance (20). In the studies conducted with high-level athletes, it was reported that maximal oxygen consumption increased in some training related to the duration of taper, but did not show any change in others (5, 21, 22, 23, 24). In a study conducted on cycling athletes about the subject, it was found that the VO₂(max values of the athletes increased by 6% as a result of decreasing the weekly training intensity by 50% for 7 days. As a natural consequence of this change, an increase of 5.4% was determined in the racing performance of the athletes against 20 km time (25). On the other hand, in another study, as a result of applying taper training to athletes for 7 days and gradually reducing the training intensity from 30% to 80%, there was no increase in the VO₂ max values and performances of the athletes. For the same group, it was determined that there was an increase of 2.5% in the VO₂ max values of the athletes and a 4.3% increase in their simulated performances by maintaining the training intensity and decreasing the training scope. However, in the same study, positive statistically insignificant differences were determined in VO₂ max values (1.1%) and simulated performances (2.2%) of the athletes with the protection of the training scope and the reduction of training intensity (25). In another study on the subject, 3 different taper were practiced on 20 elite cyclists, which lasted 7 days, with 30-50% and 80% volume reductions. As a result of these different practices, it was determined that the athletes in the group with 50% volume reduction had better performance outcomes. Although the VO₂ max values obtained as a result of the study were not statistically significant, it was reported that the VO₂ % max values of the athletes in the group with 50% volume reduction increased from 86.9% to 90.7% (15). In a study on elite athletes by Luden et al.(2010), the training volume was gradually reduced by 73% in the first two weeks and 50% in the third week. After the taper training, it was determined that there was a 0.86% decrease in the MaxVO₂ values of the athletes and 3% increase in their performance (26). In another study held by Skovgaard et al. (2017), it was reported that there was a decrease in VO₂ max values of athletes after 18-day taper practice (19).

These results, together with previous findings, show that **training intensity** is the key element to maintain or increase compliance with training stimuli and optimize sporting performance.

Table 1 includes studies investigating the effects of taper training practiced during exercise by sports scientists on VO₂ max.

Table 1. Effects of the taper on maximal oxygen uptake (VO₂ max)

	Athletes	Taper duration (days)	VO ₂ max	Performance measure	Performance outcome (%)
Van Handel et al. (1988)	Swimmers	20	↔	NR	NR
Houmard et al. (1990)	Runners	21	↔	5 km indoor race	↔
D'Acquisto et al. (1992)	Swimmers	14-28	↔	100 m / 400m time trial	↑ 4.0-8.0

Jeukendrup et al. (1992)	Cyclists	14	↑	8,5 km time trial	↑ 7.2
McConell et al. (1993)	Runners	28	↔	5 km time trial	↓ 1.2
Rietjens et al. (2001)	Cyclists	21	↔	Incremental maximal test	↔
Dressendorfer et al. (2002)	Cyclists	10	↑	20 km simulated time trial	↑ 1.2
Neary et al.(2003)	Cyclists	7	↑	20 km simulated time trial	↑ 5.4
Neary et al.(2003)	Cyclists	7	↑	40 km simulated time trial	↑ 2.2-4.3
Margaritis et al. (2003)	Triathletes	14	↑	30 km time trial	↑ 1.6-3.6
Neary et al. (2005)	Cyclists	7	↑	20 km time trial	↑ 1.09
Luden et al. 2010	Runners	21	↓	8 km time trial	3
Skovgaard et al. 2016	Long distance	18 days	↔	10-km time trial	↔

NR = not reported; ↓ indicates decreased; ↑ indicates increased; ↔ indicates unchanged (Mujika et al.,2004

1.2. Economy of Movement

Movement economy is expressed as the amount of oxygen consumed during a submaximal intensity exercise. Considering the related literature, it is seen that taper practices contribute to the development of the movement economy of athletes (27, 28). In a study examining the submaximal energy consumption values of athletes, two groups of 18 male and 6 female distance runners, who were gradually increasing for 7 days of running and cycling, were practiced taper by reducing the total training intensity to 85%. A reduction of 7% (0.9 kcal / min) was found in the athletes' submaximal energy consumption calculated for peak oxygen consumption of 80% on the treadmill. It has been reported that this increase in the economies of movement of athletes in consequence of taper practice occurs as a result of the addition of structural and biomechanical factors together with the increase in neural speed and mitochondrial capacity in the muscles (28).

1.2. Cardiac Function and Dimensions

1.2.1. Resting Heart Rate: In the literature, it is seen that there are few studies on the effect of tapering on the resting heart rate of athletes. When the literature on the subject is examined, it was found that the resting heart rate of athletes did not change as a result of the taper (29, 30).

(Table2). In another study conducted on swimmers, it was reported that the resting heart rate of athletes did not change before and after a 2-week taper application at different levels (31).

1.2.2. Maximal Heart Rate: Considering the results of the studies investigating the effect of taper on the maximal heart rate, it was found that they were not compatible with each other. In some studies, it was reported that the maximal heart rate values of the athletes did not change, and decreased or increased in others (32, 33) (Table 2). In a study conducted on swimmers, it was found that after 2 and 4 weeks of different taper training, there were slight decreases in the maximal heart rate values of athletes (32). In addition, in another similar study conducted on athletes, it was determined that the maximal heart rate values of athletes did not change after the taper phase (34).

1.2.3. Submaximal Heart Rate: When the relevant literature is reviewed, it has been reported that, in a submaximal exercise, the results of some studies conducted in different sports branches in which the heart beat numbers of athletes were examined were not compatible with each other.

Table 2. Effects of the taper on heart rate (HR)

Study (year)	Athletes	Taper duration (days)	Resting HR	Maximal HR	Submaximal HR	Performance measure	Performance outcome (%)
Houmard et al.(1990)	Runners	21	NR	↑ (slightly)	↔	5 km treadmill time trial	↔
D'Acquiso et al.(1992)	Swimmers	14-18	NR	↓	↔	100m/400m time trial	↑ 4.0–8.0
Jeukendrup et al.(1992)	Cyclists	14	↓	↑	↑	8.5 km simulated time trial	↑ 7.2
McConell et al.(1993)	Runners	28	↔	↑ (slightly)	↔	5 km simulated time trial	↓ 1.2
Houmard et al.(1994)	Runners	7	NR	↔	↑ (slightly)	5 km simulated time trial	↑ 2.8
Stone et al.(1996)	Weightlifters	7-28	↔	NR	↔	Competition	↑ 8.0-17.5 kg
Hooper et al.(1999)	Swimmers	14	↔	↑ (slightly)	NR	100 m time trial	↔
Martin and Andersen (2000)	Cyclists	7	NR	↑ (slightly)	↔	Incremental maximal test	↑ 6.0
Dressendorfer et al. (2002)	Cyclists	10	NR	NR	↔	20 km time trial	↑ 1.2
Neary et al. (2003)	Cyclists	7	NR	NR	↔	20 km simulated time trial	↑ 5.4

NR = not reported; ↓ indicates decreased; ↑ indicates increased; ↔ indicates unchanged (Mujika et al.,2004)

1.2.4. Blood Pressure: It has been observed that there are very few studies in the literature investigating the effects of taper on blood pressure. In a study on the subject, it was found that diastolic blood pressure

decreased by 2.2% and systolic blood pressure by 3.4% in swimmers (29). In another similar study, it was reported that systolic blood pressure decreased from 114 mm Hg to

112 mm Hg, and diastolic blood pressure increased from 73 mm Hg to 74 mm Hg in runners (35).

1.2.5. Cardiac Dimensions: In a study conducted on swimmers on the subject, firstly, the athletes were trained at altitudes of 1050 m and 1848 m for 3 weeks, then through reducing the training intensity by 73%, 2 weeks taper training practiced. According to the results of the study, it was determined that there was no significant change in the structural and functional states of the athletes' hearts (31).

1.3. Respiratory Function: Respiratory exchange ratio (RER) is defined as the ratio of the amount of carbon dioxide produced by the individual per unit time to the amount of oxygen consumed (36, 16). In the literature, there are very few studies investigating the effects of taper on respiratory function and their results are inconsistent. It was observed that there was no change in the RER value of the athletes during maximal exercises such as 20 km running after taper training. After 7 days of taper training combined with a high-carbohydrate diet, an increase in RER value and carbohydrate oxidation was reported after cycling exercise at 80% of VO₂ max. In the same study, it was reported that the amount of oxygen inhaled by athletes decreased from 25.5 L / LO₂ to 24.0 L / LO₂ (25). In a study on endurance athletes by Skovgaard et al. (2017), a 18 days taper was done. After the taper, the athletes were tested for 10 km running at 60% of their VO₂ pace of running. It was observed that there was a decrease in athletes' RE values before and after the run (19).

1.4. Hematological Levels: Considering the literature on the subject, in a study conducted on athletes, it was reported that athletes' blood volume and red blood cells increased after taper (37). After 7 days of taper training of athletes, it was determined that there was a 15% increase in the total blood volume. It has been stated that it is caused by the increase in plasma renin and vasopressin activity during (18). In addition, in another study, it was determined that there were slight increases in haematocrit and haemoglobin concentrations during taper training for competitive swimmers (38). In addition, in another study conducted with high-level swimmers, it was found that there was a decrease in the red blood cells of athletes after 12 weeks of low-intensity and 4 weeks of high-intensity taper training (39).

1.5. Enzyme Levels: Biological catalysts in protein structure that can be synthesized by living things are called enzymes. Creatine Kinase (CK) is a type of enzyme produced in many different tissues and cells and provides body energy. The level of CK in the blood is known to be used as an indicator of training intensity. In studies on the subject, it has been reported that, during taper training, CK levels in athletes' blood decrease while athletes' oxidative

enzyme and ATPase levels increase (35, 40, 41, 25). (Table 3).

1.6. Hormone Levels: Hormone is a chemical substance excreted from endocrine glands to carry out inter-cellular communication and carried to various organs and tissues by blood, regulating their structure and functions according to the needs of the body. When we look at the related literature, it has been observed in many studies that while the testosterone levels of athletes increased after taper, there was a decrease in cortisol levels (40, 42, 41, 10, 43). However, in some studies, it was found that athletes had slight increases in the testosterone / cortisol ratio after taper. It has been stated that the increase in this ratio is related to the improvement in the performance of swimmers (10). Plasma nor adrenaline concentration is a marker known to be associated with recovery. However, the role of catecholamines in recovery after intense training is not fully known. In a study conducted on elite swimmers, it was determined that there was no change in plasma adrenaline, nor adrenaline and dopamine concentrations after 4 weeks of taper training (10). IGF is a hormone known as muscle growth factor. It has been reported that there is a 10% increase in the IGF value as a result of 3 weeks of intense exercises, whereas there is a 30% decrease in the IGF value after 2 weeks of taper training (44) (Table 3).

In a study conducted by Mujika and Padilla (2000) on 8 middle distance runners, a 6-day taper was implemented to athletes and it was found that there was increase in testosterone and growth hormone, while a decrease in creatine kinase level, red blood cell count and some oxidative enzyme activities (45). In a study by Frahangimalaki et al. (2009) on 24 long-distance elite cyclists, it was reported that after 3 weeks of tapering with a training intensity reduced by 50%, there was an increase in athletes' performance, while a decrease in IL-1 beta, IL-6 and TNF alpha levels was observed in the third week after tapering. As a result of the study, after 2000 meters of rowing ergometer, while an 8% decrease in the leptin levels of the athletes was reported, a 9% increase in the testosterone levels was observed (46). In another similar study on the subject, 11 male athletes who did strength training were implemented a 7-day taper after an 8-week strength training program. According to the study findings, it was reported that there was no change in athletes' testosterone, cortisol and creatine kinase levels (47). In the study by Skovgaard et al. (2017), after 10 days taper training, 10 km running test was held on the athletes and its effects on athletes' performance and muscular adaptation were investigated. As a result of this study, it was found that plasma epinephrine and norepinephrine values increased (19).

Table 3. Hematological Changes Resulting from Taper

Hormone	Cortisol	↓	
	Testosterone	↑	
	T/C Rate	↑	
	IGF (3 weeks practice)	↑	
	IGF (2 weeks practice)	↓	
	IL-1 Beta (Practiced 3 weeks later)	↓	
	IL-6 (Practiced 3 weeks later)	↓	
	TNF Alfa (Practiced 3 weeks later)	↓	↓
Leptin	↓		

	Adrenalin	↔
	Nor adrenalin	↔
	Dopamine	↔
Enzyme	Creatine kinase	↓
	Oxidative Enzyme	↑
	ATPase	↑
Energy	Muscle Glycogen	↑

NR = not reported; ↓ indicates decreased; ↑ indicates increased; ↔ indicates unchanged

2. Metabolic Changes

2.1. Blood Lactate Kinetics

2.1.1. Maximal Exercise: Studies on the subject in the literature show that as a result of taper training, there are significant increases in the blood lactate concentrations of athletes after maximal exercise (24, 32, 48, 37). (Table 4). It is stated that this change, which may be associated with the increase in muscle glycogen stores after taper, may cause an increase in the maximal performance capacity of athletes (28). In a study conducted on male cyclists on the subject, a 14-days taper training was implemented to athletes and it was found that the blood lactate concentrations of athletes increased by 78%. In addition, in the 8.5 km (outdoor time trial) race, it was determined that there was an improvement of 7.2% in the athletes' performances and 10.3% in their maximal power output.

2.1.2. Submaximal Exercise: Considering the studies conducted on the subject in the literature, it has been

determined that there are inconsistent changes in the intensity of submaximal exercise and the blood lactate concentrations of athletes (49, 32, 34,50) (Table 4). In a study on the subject, after 2 and 4 weeks of taper implemented to high school female athletes, it has been determined that the blood lactate levels during submaximal intensity swimming exercise decreased between 15-26% in the 2-week taper, and 26-33% in the 4-week taper. (30). In addition, in another study, it was reported that the blood lactate concentrations of athletes did not change in exercises at submaximal intensity (75% for runners and 90% for swimmers) after the taper phase (35). In their studies, Skovgaard et al. (2017), they conducted 10 km running test on athletes after 18 days of taper. They took blood from the athletes and examine the blood lactate values before and after the test. It was observed that in the blood taken 3 minutes after the end of the test, the blood lactate levels of the athletes decreased significantly (19).

Table 4. Effects of the taper on blood lactate concentration (H[La])

Study (year)	Athletes	Taper duration (days)	Peak H[La]	Submaksimal (H[La])	Performance measure	Performance outcome (%)
Costill et al. (1985)	Swimmers	14	NR	↓	46-1509 m Competition	↑ 2.2-4.6
D'Acquisto et al. (1992)	Swimmers	14-28	↑	↓	100 m /400m time trial	↑ 4.0-8.0
Jeukendrup et al. (1992)	Swimmers	14	↑	NR	8.5 km outdoor time trial	↑ 7.2
Johns et al. (1992)	Swimmers	10-14	NR	↔	46-366 m Competition	↑ 2.0-3.7
McConell et al.(1993)	Runners	28	NR	↑	5 km indoor time trial	↓ 1.2
Flynn et al. (1994)	Swimmers	21	NR	↔	23-366 m time trial	↑ 3.0
Kenitzer (1998)	Swimmers	14-28	NR	↓14 days ↑ 21-28 days	4 x 91 m submaksimal set	↑ 4.0
Steinacker et al.(2000)	Rowers	7	↑ (slightly)	NR	2000 m	↑ 6.3
Rietjens et al. (2001)	Cyclists	21	NR	↔	Incremental maximal test	↔
Mujika et al.(2002)	Runners	6	↑	R	800 m Competition	↑ 0.4-1.9
Skovgaard et al., 2017	Runners	18	NR	↓	10 km time trial	↑ 2.7

NR = not reported; ↓ indicates decreased; ↑ indicates increased; ↔ indicates unchanged (Mujika et al.,2004)

2.2. Muscle Glycogen Levels

In the literature, some changes have been observed in the muscle glycogen concentrations of athletes after taper training (41, 15, 51). In a study on the subject, it was reported that the muscle glycogen storage of athletes increased by 25% after a taper lasting 8 days, and by 17% after a 4-day taper (15). In another study, it was found that the increase in glycogen stores of female athletes after taper was higher than that of male athletes (52).

3. Neuromuscular Changes

3.1. Strength and Power

According to the studies conducted, it was found that there are significant improvements in strength and power levels of athletes as a result of the taper training (53, 16, 11, 54, 55, 56, 57) (Table 5). In a study conducted on swimmers in which strength and power output were examined, it was determined that after a 2-week taper, there was an increase of 18% in arm strength measured in accordance

with the swimming biokinetics of athletes and a 25% increase in current swimming strength (in distance). At the same time; It was also reported that as a result of this increase in arm strength measured biomechanically, there was an increase of 3.1% in performance of athletes in the general competition (49). Similar results were obtained in another study conducted on cyclists. As a result of the incremental maximal test applied to cyclists after taper, it was determined that there was an 8.0% improvement in the performance levels of the athletes (58).

In a study by Izquierdo et al. (2007) on 11 physically active men, a taper training was implemented for 4 weeks following 16 weeks of strength training, and it was reported that there were 2% -3% increases in the bench press and squat strength of athletes (42). In another similar study, it was stated that there was an increase of 5-6% in the running distance of distance runners after taper training (8). In the study conducted by Grgic and Mikulic (2017) on 10 powerlifting champions, athletes did taper training for 8 to 2

days before the championship with an average reduction of 50% in training intensity. All athletes stated that taper training applied before the competition positively affected their performance during the competition (59). In the study by Pritchard et al. (2018) on 11 athletes, taper was implemented to the athletes for 7 days after intensive work. It was determined that there was a statistically significant improvement in the athletes' vertical jump performance and the contraction times during jumping. In the same study, it was reported that athletes had an increase in bench press strength and isometric mid-thigh pull strength (47).

In a study conducted by Vachon et al (2020), the effects of taper on the metabolic fitness and nervous muscular system of athletes who do team sports were examined by using meta-analysis. As a result of this study, the researchers found that there was an increase in the repetitive sprint performance ((SMD) (95% IC; I2) = 0.41), maximal power ((SMD (95% IC; I2) = 0.44), and direction change speed ((SMD (95% IC; I2) = 0.38) 60).

Table 5. Effects of the taper on muscular strength and power

Study (year)	Athletes	Taper duration (days)	Strength and/or power	Performance measure	Performance outcome (%)
Costill et al. (1985)	Swimmers	14	↑	46-1509 m Competition	↑ 2.2-4.6
Cavanaugh and Musch (1989)	Swimmers	28	↑	46-1509 m Competition	↑ 4.0-8.0
Johns et al. (1992)	Swimmers	10-14	↑	46-366 m Competition	↑ 2.0-3.7
Shepley et al.(1992)	Runners	7	↑	Treadmill time trial	↑ 6.0-22.0
Martin et al. (1994)	Cyclists	14	↑	Incremental maximal test	↑ 8.0
Trappe et al.(2000)	Swimmers	21	↑	Competition	↑ 3.0-4.7
Zaras et al. (2014)	Runners	7	↑	Strength performance	↑ 5.0-6.0
Pritchard et al.(2018)	Strength trained	5	↑	Isometric bench press	↑ 1.0 -4.0
Pritchard et al.(2018)	Strength trained	5	↑	Isometric mid-thigh pull	↑ 2.0-3.0
Hermassi et al(2019)	Handball	14	↑	Lower limbs	↑ 12.1
Hermassi et al(2019)	Handball	14	↑	Bench pres	<0.001
Hermassi et al(2019)	Handball	14	↑	Running shot (m/s)	<0.001
De Lacey at al.(2014)	Rugby	21	↑	Jump height	↑ 35
Rhibi et al. (2016)	Sedentary (28 man)	14	↑	Counter-movement jump	↑ 5
Pitchhard et al.(2018)	Strength trained	5	↑	Counter-movement jump	↑
Hermassi et al(2019)	Handball	14	↑	Counter-movement jump	↑ 4

↓ indicates decreased; ↑ indicates increased; ↔ indicates unchanged (Mujika et al.,2004)

4. Changes in Muscle Fibre

4.1. Muscle Fibre Size

In the literature, it has been reported that there are some changes in athletes' fibril structure as a result of taper (61, 62, 63, 64, 65). In a study conducted on male swimmers, it was found that after a 3-week taper, there was no change in athletes' type 1 fibre diameter and in cross-sectional area, but type 2a fibre diameter increased by 11% and cross-sectional area increased by 24% (65). In another study, 7-day high intensity (85-90% of maximal HR) and low volume (gradually decreasing from 60 minutes to 20 minutes) taper were implemented on male cyclists. It was

observed that athletes had an increase of 6.9% in type 1 fibres' cross-sectional area and a 14% increase in type 2 fibres' cross-sectional area. In a low intensity (maximal HR gradually decreasing from 85% to 55%) and high density (60 min for each unit), a 7% increase in type 1 fibres of athletes and an 11% increase in type 2 fibres were detected (25). Luden et al. Conducted a 21 days taper study on athletes. In this taper there was a decrease in training intense of 27% in the first and second weeks; and 50% on the third week. After taper, it was reported that 15% growth was observed in athletes' type 2 fibril diameter, while a 7% increase in the type 2 fibril strength.

In another similar study conducted on professional volleyball players, it was found that athletes' jumping performance did not change after the taper training by reducing the volume by 20% -40%, but there was a decrease in the diameter of the quadriceps muscle fibres and that these levels were better than the pre-season values. On the other hand, it has been reported that there is no change in muscle fascicle length, pennation angle (angle of incidence of muscle fibers into the tendon) and jump height levels (66).

4.2. Metabolic Properties

It has been determined that there are few studies on the subject in the literature. In a study conducted on cycling athletes, it was determined that after a high intensity/low-volume taper, ATPase increased by 11% and succinate dehydrogenase enzyme increased by 12% in type 1 fibres. A 15-16% increase was detected in ATPase, succinate dehydrogenase, acyl-CoA dehydrogenase and cytochrome c oxidase (complex IV enzyme) enzymes in type 2 fibres. It has been determined that these changes provide a 4.3% increase in the 40 km bicycle racing performance of the athletes (64).

CONCLUSIONS

It has been observed that taper brings about some physiological changes in athletes' organisms and in this case it contributes to the performance improvement of athletes. Due to intense training, athletes' physiological structures deteriorate and their performance decreases. In the taper phase, the stimuli are greatly reduced, so the recovery of the athletes before important competitions is faster and their performance reaches the optimal level.

The implementation of taper strategies in elite sports is largely determined by daily interaction with athletes, based on the coaches' own observations and experiences. Trainers, who prepare elite athletes for important competitions, can create significant physiological changes in athletes with a well-designed taper program and contribute to athletes' performance improvement.

As a result of a systematic review of the limited number of studies in the literature, it may be concluded that more studies are necessary to investigate the effects of taper training on different sport branches in which both aerobic and anaerobic metabolisms are active.

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