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The Effects of Tapering on Performance in Elite Endurance Runners: A Systematic Review

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Abstract The purpose of this study was to perform a systematic review determine the effects of tapering on performance in elite endurance runners. The taper is a key element of the physical preparation of athletes in the weeks before a competition and it seems that the most important variable for maximize performance is training volume, training frequency and intensity. Three electronic databases were searched for original research articles. Nine studies met the inclusion criteria. The training volume is exponentially decreased by 17.6-85%. Two of studies showed that improve VO_{2max}, whereas the other 4 studies found maintenance of VO_{2max}. Six of the 9 included studies showed to improve the performance, two studies didn't find significant changes of performance and one study found reduces of performance. Four of studies found reductions in training frequency and the five remaining studies showed a maintenance of training frequency.

Keywords Tapering, Performance, Endurance Runners

1. Introduction

The aim of coaches and athletes is to increase the physical, technical and physiological abilities at the top possible levels, and develop a precisely controlled training program to ensure that maximal performance is achieved in major competitions [16].

To bring an athlete to a peak performance is an art and a science. Tapering is the reduction in training load before competition [17, 21, 29] or the final period before a major competition [26] and it is very important for the athlete's performance. The aim of tapering is to maximize physiological adaptation with reduction of accumulated fatigue [3, 17, 20]. Furthermore, the main objective of tapering is to minimize the negative physiological and psychological impact of daily training rather than to attain additional physiological adaptations or fitness gains in preparation for an athletic competition [7, 25, 26]. Tapering can be achieved by using the training load variables such as volume, frequency, duration and intensity [10, 32] but the type of training differs from sport to sport and athlete to athlete [4]. There is a thin line between maximizing the performance and overtraining or detraining. The balance between the reduction of training volume and the period of time employed to elicit a peak is crucial if optimal tapering is to be achieved. If the taper period is too long, or the reduction of training volume is too rapidly, then sufficient training stimulus may not be provided to prevent a detraining or an overtraining effect [13]. A common mistake about tapering for coaches and athletes is to reduce training load or intensity immediately before a competition may decrease exercise performance through detraining [23, 33]. It has been observed that after a reduction of training by 14-21 days, athletes can begin to show symptoms of detraining [13], so the line between tapering and detraining is crucial. On the other hand, if the tapering period is not administered, overtraining may occur in a competitive athlete [19]. Each of these situations may result in athletes missing their peaks, thus compromising optimal performance and undoing an otherwise well designed training program. Therefore, the taper period is a critical period for coaches, sports scientists and athletes. One other strategy is that many athletes may use to taper after a competitive season for recovery from psychological and physiological stresses associated with major competition or intense training [13].

It is very difficult for athletes, coaches and researchers to find strategies to increase performance in elite endurance runners. Have been reported in the literature many strategies to decrease the training load and most of them improve performance of athletes [3, 10, 12, 20, 28]. Based on meta-analysis of 27 studies, Bosquet et al. [3], recommended that the best strategy to improve performance is a 2-week tapering intervention which training volume reduced by 41-60%, without altering training intensity or frequency.

Previous review articles on the effects of tapering on performance in elite endurance runners did not perform a systematic review because they only summarized the

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available data. Thus, the aim of this study was to systematically review the body of scientific literature for original research, addressing the effects of tapering on performance in elite endurance runners.

2. Methods

2.1. Experimental Approach to the Problem

A literature search was conducted on 24 October 2017. The following databases were searched: Pubmed, SPORTDiscus and Medline. Databases were searched from inception up to October 2017, with no language limitation. Abstracts and citations from scientific conferences were excluded.

2.2. Literature Search

In each database the title, abstract and keywords search fields were searched. The following keywords, combined with Boolean operators (AND, OR), were used: "tapering", "performance", "training", "reduce training", "endurance runners", and "elite athletes". No additional filters or search limitations were used.

2.3. Inclusion Criteria

Studies meeting the following criteria were considered for the review: 1) participants of the study had to be elite or competitive athletes in middle and/or long distance running; 2) participants had a VO_{2max} value > 55mL·kg^{-1}·min^{-1}; 3) the study must employ a tapering intervention and give all details about the procedures used to decrease the training load and 4) at least one outcome measure of performance was reported.

3. Results

3.1. Studies Selected

Search strategy yielded 1118 total citations as presented in Figure 1. After removing duplicates and reviewing the resultant 83 full-text articles, 9 studies met the inclusion criteria [11, 12, 14, 17, 18, 24, 25, 30, 31]. Excluded studies had at least one of the following characteristics: (a) participants had VO_{2max} values < 55 ml·kg^{-1}·min^{-1}; (b) participants were not middle and/or long distance runners; (c) training volume and training frequency were not measured; (e) performance was not measured. Thus, the overall sample for the present meta-analysis resulted in 124 high-level middle- and long-distance runners with VO_{2max} > 55 ml·kg^{-1}·min^{-1}.

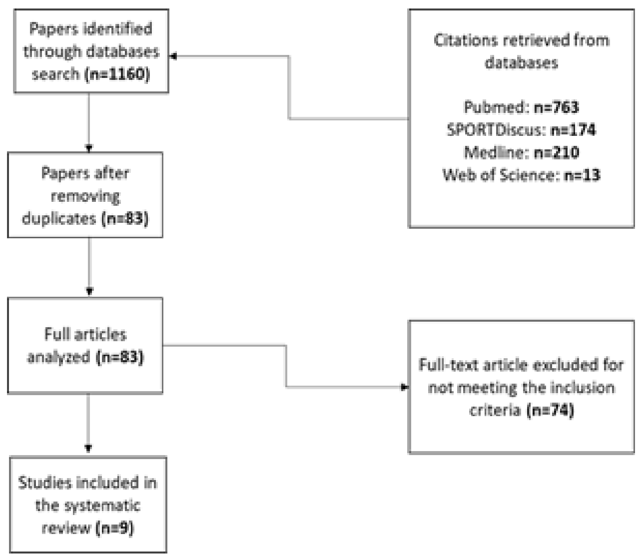

Figure 1. Flow chart of search strategy and selection of articles

3.2. Characteristics of the Participants

A summary of participants' characteristics is presented in Table 1. The total number of participants was 125 (100 males and 25 females) with an age ranging from 19.9 to 34.6 years. Participants' VO_{2max} ranged between 55.3-69.7 ml·kg^{-1}·min^{-1}. All participants competed in middle- and long-distance running events at national and/or international level.

3.3. Characteristics of the Training Programs

The characteristics of the training programs of each study are depicted in Table 1. According to the reported data, in these competitive athletes, maximal gains are obtained with a tapering intervention of 6 days to 28 days duration. Three studies used 6 days tapering [24, 25, 32], 1 study used 7 days tapering [12], 1 study used 18 days tapering (31), 3 studies used 21 days tapering [11, 14, 17], and 1 study used 28 days tapering [18]. The changes in training variables are presented in Table 2. The training volume is exponentially decreased by 17,6-85%. Three studies found that improve VO_{2max} by 1.51-5.3% [11, 12, 14, 22] and other 3 studies found reduces of VO_{2max} by 0.86-1.45% [11, 17, 18]. Six of 8 studies improve the performance by 0.31-3% [11, 12, 17, 24, 25, 31]. One study found that reduce performance by 1.2% [18]. One study measured Tlim and found increased of time by 20.0% [14]. Four of studies found reduce of training frequency from 14.28% to 77.7% [11, 14, 18, 32]. The five remaining studies showed a maintain of training frequency [12, 17, 24, 25, 31].

Table 1. Characteristics of the studies and the participants*

Study	n	Athletes	Duration of tapering	Volume decrease (%)	Training volume (km/wk)		Training frequency (days)		VO_2max ($ml.kg^{-1}.min^{-1}$)		Performance (s)		Performance measure
					Pre tapering	Post tapering	Pre tapering	Post tapering	Pre tapering	Post tapering	Pre tapering	Post tapering	
Spilsbury et al. 2015	37	Middle distance	6 days	30	64	44.8	7	3	Not measured		Not measured		Not measured
		Long distance	6 days	30	101	71.7	9	2	Not measured		Not measured		Not measured
		Marathon	14 days	47	158	83.7	11	1	Not measured		Not measured		Not measured
Hug et al. 2014	9	Marathon	21 days	33	Not reported		7	6	59.5 ± 2.9	60.4 ± 2.6	603 ± 105	727 ± 185	Tlim
Luden et al. 2010	7	Long distance	21 days	50	72	36	6	6	69.7 ± 0.1	69.1 ± 0.1	1662 ± 21	1612 ± 27	8-km running
Mujika et al. 2002	9	Middle distance	6 days	Taper 1 – 20	39.2 ± 9.5	31.36 ± 7.6	6	6	Not measured	Not measured	124.2 ± 4.9	121.8 ± 4.7	800-m running
				Taper 2 – 33	35.5 ± 5.5	28.4 ± 4.4					127.1 ± 2.1	126.6 ± 2.8	
Mujika et al. 2000	8	Middle distance	6 days	Taper 1 – 50	43.9 ± 6	21.9 ± 3	6	6	Not measured	Not measured	125.7 ± 6.6	126.2 ± 8.0	800-m running
				Taper 2 – 75	43.4 ± 8.3	10.8 ± 2	6	6			126.1 ± 4.2	124.9 ± 4.5	
Houmard et al. 1994	24	Long distance	7 days	85	74.7 ± 8.4	11.2	7	7	55.3 ± 2.2	57.0 ± 2.3	1044.3 ± 24.6	1020.0 ± 24.7	5-km running
McConnel et al. 1993	10	Long distance	28 days	66 %	71.8 ± 3.6	24.8 ± 0.3	6	3	63.5 ± 1.1	62.8 ± 1.3	996 ± 18	1008 ± 18	5-km running
											363 ± 19	369 ± 22	Tlim
Houmard et al. 1990	10	Long distance	21 days	70	81.3 ± 5	24 ± 2	6	5	61.8 ± 1.1	60.9 ± 1.2	1008.6 ± 12.1	1004.0 ± 11.8	5-km running
Skovgaard et al. 2016	11	Long distance	18 days	49	17 ± 1	14 ± 1	6	6	56.8 ± 2.9	Not measured	2442 ± 42	2442 ± 36	10-km running

*n = number of athletes; VO_{2max} = maximal oxygen consumption

Table 2. Changes in training variables

Study		Training volume % change	Training frequency % change	VO_2max % change	Performance % change
Spilsbury et al. 2015	Middle distance	-30	-57.1	-	-
	Long distance	-30	-77.7	-	-
	Marathon	-47		-	-
Hug et al. 2014		-	-14.28	1.51	-20
Luden et al. 2010		-50	0	-0.86	3
Mujika et al. 2002	Taper 1	-20	0	5.3	0.31
	Taper 2	-33			0.39
Mujika et al. 2000	Taper 1	-50	0	-	0.39
	Taper 2	-75	0	-	0.95
Houmard et al. 1994		-85	0	3.07	2.32
McConnel et al. 1993		-66	-50	-1.1	-1.2
Houmard et al. 1990		-70	-20	-1.45	0.45
Skovgaard et al. 2016		-17,6	0	-	2.7

4. Discussion

The purpose of this study was to assess the effects of tapering on performance in competitive athletes, through a systematic review of the literature.

The taper is a key element of the physical preparation of athletes in the weeks before a competition and it seems that the most important variables for maximize performance is training volume, training frequency and intensity.

In this systematic review, several studies support the reduction of training volume, the reduction or maintain of training frequency and maintained or increased the intensity to improve performance. Moreover, Houmard et al. [12] found 2.32% improvement in performance at 5km training time and increased the VO_{2max} by 3.07% with a maintained training frequency. Suggested a 7 days of tapering with reduces training volume at 85%. Also, Shepley et al. [30] compared the effects of a 7 day 62% reduction in volume with a 7 day 90% reduction in volume. They found that only the 90% reduction increase the time to exhaustion by 22%. The same study used three different types of tapers on the athletic performance of middle-distance runners. The first was a high-intensity low-volume taper, the second was a low-intensity moderate-volume taper, and the final strategy was a rest only taper. They found that only the high-intensity low-volume taper significantly improving performance on an exhaustive treadmill run and increasing the time to fatigue. Also found better physiological and performance results with a low-volume taper than with a moderate-volume taper. Luden et al. [17] used 3 weeks of tapering with reduce the volume training the first 2 weeks by 73% and the third week by 50%. Also, they maintain training frequency before and after 3 weeks of tapering. They found not significant change in VO_{2max}, but 8km race performance improved by 3%. Harber et al. [8] found a 1.8% improvement in 8 km outdoors following a 4 weeks taper. In addition, Hug et al. [14] used 3 weeks of tapering with reduction of training volume and training frequency by 33% and 14% respectively. Pre and after tapering the athletes ran at an individual running speed corresponding to 95% of the velocity associated with VO_{2peak} (VO_{2peak}) until exhaustion. They found that the time of this test increased after tapering, but not significant change in VO_{2max}. In the study of Mujika et al. [24] middle distance runners were assigned to a high frequency taper or a moderate frequency taper during a 6 day taper with reduction of training volume by 80%. Performance improved significantly after high frequency taper, but not after moderate frequency taper. In addition, Spilsbury et al. [32] reported reduce training frequency by 57.1% in middle distance runners and 77.7% in long distance runners followed by 6 days of tapering. Furthermore, Skovaard et al. [31] examined the effect of a 18 days reduction in training volume (-17.6%). Also, they maintain training frequency before and after 18 days of tapering. They found that 10 km running performance improved by 2.7%.

On the contrary, two of studies used the reduction of training volume and training frequency and found not significant changes in performance times. Houmard et al. [11] reduced weekly training volume and training frequency by 70% and 20% respectively. They found not significant changes in 5 km race times and in VO_{2max} in long distance runners during 3 weeks of taper. Similarly, Mujika et al. [25] compare the effects of 6 days 50% reduction in volume with a 75% reduction in volume. The results shown that performance was not significantly enhanced by either taper protocol. But better 800 m running performances were achieved when training volume was reduced by 75% than by 50%. Finally, one of the studies found reduces of performance. McConnell et al. [18] examine the effects of a 4 weeks reduction in training volume (-50%) and in training frequency (-50%) and they found that 5 km running performance reduced (-1.2%) after 4 weeks. Also, they observed not significant change in VO_{2max}.

However, the large discrepancies in performance aren't surprising. The three of previous studies [11, 18, 25] found reductions or maintenance of performance. This discrepancy could in part be attributed to the different performance measurements used. Differences in the tapering strategy could also be responsible for the discrepancy in performance improvement.

5. Conclusions

Tapering can be achieved by manipulating the training load variables of volume, frequency and intensity. Training volume must be reduced, training frequency must be reduced or maintained to improve performance with duration 6 days – 4 weeks. It has been observed that correct tapering would improve marathon performance up to 3 percent [9]. So, concluded that the tapering is an essential training strategy for improving performance and bringing success in a major competition.

The main limitation of the present systematic review is the small number of included studies. Although the role of tapering in the improvement of running performance has received a lot of attention during the last decade [3, 22], the vast majority of the studies recruited amateur-recreational runners or different sports (swimming, triathlon, cycling) [1, 2, 5, 6, 27, 34] instead of highly trained middle and long distance athletes [11, 12, 14, 17, 18, 24, 25, 30, 31]. Considering that highly trained runners have different tapering techniques than non-elite athletes, future research analysing elite runners is therefore necessary. This may provide valuable information for coaches and applied scientists about the ongoing management of elite running training programmes and may be especially relevant in the context of a multifactorial approach to reach historic milestones such as the sub-2h marathon [15].

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