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Effects of different rates of reduction in mileage during the tapering period on 3,000 m time and physiological and psychological indices in middle- and long-distance runners in junior high school students

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[Abstract]

This study aims to examine the effects of different rates of reduction in mileage during the tapering period on 3,000 m time and psychological indices and Root Mean Square of Successive Differences of RR intervals (RMSSD) in junior high school runners. 12 male junior high school student runners (13.5 ± 0.5 years, 3,000 m time: 10:25.39 ± 48.76) were implemented two types of tapering, each 7 days, in which the mileage was reduced by about 20% (slight tapering) or about 40% (recommended tapering) from generally training period. Then, before and after tapering, the participants performed a 3,000 m Time Trial (TT). RMSSD and "Fatigue" and "Tension" scale scores by measured POMS2 were measured at 1, 4, and 7 days, and on the day of TT implementation of the two types of tapering periods. No significant main effects or interactions were observed for differences in tapering and for time of TT before and after tapering. On the other hand, the fatigue score decreased from the 1 day of tapering to the day of implementing TT, but was lower at recommended tapering. RMSSD increased from the 7 day of tapering to the day of implementing TT, but was higher at recommended tapering. The results of this study suggest that both recommended tapering and slight tapering suppress the detraining effect. However, recommended tapering may be more beneficial for reduction of psychological fatigue and parasympathetic nervous system activity.

Keywords : tapering, junior high school student, middle- and long- distance runners

1. Introduction

It is generally for middle- and long-distance runners to implement a strategy called tapering before a competition to improve running performance. According to Mujika & Padilla[17)], Tapering is defined as "a progressive nonlinear reduction of the training load during a variable period of time, in an attempt to reduce the physiological and psychological stress of daily training and optimise sports performance". This tapering is implemented by modifying the training load that consists of the volume (mileage), intensity, and frequency of training[19)]. Improvements in psychological[15)] and physiological function[20)] have been reported by implementing tapering. And, many studies reported that tapering improves performance[18)]. Above all, a meta-analysis[4)] reported an average improvement in performance of 1.96% by implementing tapering.

In tapering, it is also necessary to reduce fatigue accumulated from previous training in

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order to achieve better performance. Therefore, the mileage must be reduced while maintaining the intensity of training compared to the generally training period[4]. In the past, Witting et al.[33] reported a significant decrease in fatigue scale scores measured by the Profile of Mood State (POMS) as a result of tapering from generally training to a 70% reduction in mileage. And Houmard et al.[11] reported that tapering to reduce in mileage by 85% significantly improved the 5 km time. Moreover, Spilsbury et al.[29] reported that tapering to reduce in mileage by 30% significantly improved the 1,500 m time. Thus, there have been various discussions on the optimal rate of reduction in mileage during the tapering period. However, a meta-analysis of tapering in general adult reported that tapering with a 41-60% reduction in mileage is beneficial for performance[4].

Moreover, training intensity must be maintained during the tapering period in order to suppress the de-training effect. The de-training effect is reduction in the physiological adaptation gained from previous training and the performance[17]. For example, many runners in Japan run 1,000 m a few days before a competition[22]. And, many studies have reported that tapering, including the implementation of high-intensity training, is beneficial to performance[27), 28]. Such high-intensity training aimed to suppress de-training effects during the tapering period has been reported that many runners in Japan implement high-intensity training in 1 day before a competition[22]. On the other hand, in other countries, such as Great Britain and Kenya runners impellent high-intensity training in 3 day before a competition[27), 28]. In this way, it is important to balance the reduction of fatigue and the suppression of the de-training effects during the tapering period.

It is necessary to examine the appropriate the rate of reduction in mileage during the tapering period, focusing on “fatigue reduction” and “suppression of the de-training effects” in junior high school student runners. In the past, previous studies on tapering have focused on general adult[4], and there are many unclear points regarding how to effectively implement tapering in junior high school student runners. For example, Watanabe et al.[32] reported that junior high school student runners, the rate of reduction in mileage from 3 weeks to 1 week before a competition was about 9%. And Obata et al.[21] reported that many junior high school runners increased their mileage during the tapering period compared to other age groups. These findings [21), 32] suggest that many junior high school student runners may be implemented in the different tapering[4] that recommended for general adult. However, these studies[21), 32] only implemented questionnaires, and there are few studies that examined the effect of the rate of reduction in mileage during the tapering period on performance in junior high school student runners. In a slight previous study on junior high school student runners, Obata et al.[23] reported that running times were maintained even with a reduction rate of about 20%. However, Obata et al.[23] did not compare this strategy to the 41% reduction in mileage recommended for generally adults[4]. Therefore, it is not certain whether the tapering[4] recommended for general adult is effective for junior high school student runners. It is assumed that applying the rate of reduction in mileage that is recommended for general adult[4] with a high mileage to junior high school student runners with a low mileage would have very different implications for tapering[23].

In addition, in order to ascertain fatigue and stress conditions during the tapering period, it is necessary to evaluate them by physiological indices. Blood creatine kinase (CK) concentrations [6), 10)], testosterone to cortisol concentration ratios[18)], and catecholamine concentrations[9)], which have been used in tapering studies, require invasive procedures on subjects and expensive equipment, and are assumed to be difficult for coaches and athletes to monitor and utilize on a daily basis in competition.

On the other hand, Heart Rate Variability (HRV) is frequently used during training as a physiological index because of its simplicity of measurement. HRV is a noninvasive measurement of the R-R interval variability on the ECG and can assess autonomic nervous system activity[1)]. This HRV can be measured relatively inexpensively with commercially available sports watches and heart rate monitors. And it is also being actively utilized for runners such as graduate students[13), 14)]. In the past, HRV has often been analyzed using frequency-domain analysis, but in recent years, HRV has been evaluated using Root Mean Square of Successive Differences of RR intervals (RMSSD), which is a time-domain analysis of parasympathetic nervous system activity[31)].

RMSSD is known to be affected by changes in training load (e.g., mileage, intensity). It has been reported that RMSSD generally decreases with increasing mileage[7)] and increases with decreasing mileage by tapering[3)]. Moreover, Buchheit et al.[5)] reported that a correlation was observed between RMSSD and 10 km time, and subjects with improved performance was activated parasympathetic nerve activity. However, there have been cases reported in which RMSSD decreased by various stresses when performance was improving[13), 26)], so it cannot be said that an increase in RMSSD necessarily leads to an improvement in performance. Therefore, it has been reported that the evaluation of autonomic activity, in combination with the measurement of subjective measures, is easier to interpret [3), 13)].

Therefore, the purpose of this study was to examine the effects of different of reduction in mileage in 7-day tapering on the 3,000 m time, RMSSD as a physiological index, and scores on the "fatigue" and "tension" scales measured by the POMS2 as a psychological index.

2. Method

2.1 Participants

The participants were 13 junior high school student males (age: 13.5 ± 0.5 years, height: 160.2 ± 11.1 cm, weight: 49.7 ± 6.1 kg, 3,000 m personal best time: 10 min 25 sec 39 ± 48 sec 76) who belonged to a track and field club and specialized in middle- and long-distance events. For participants who did not have an official 3,000 m time at the time of their participation in the study, the time measured by a JAAF referee at an official track was considered as their personal best 3,000 m time. One participant was excluded from the analysis because he was not able to participate in the 3,000 m competition, which was implemented as a Time Trail (TT).

In implementing the study, the participants and their parents were informed orally and in writing about the outline of the study and its risks, and their consent was obtained. This study was implemented after obtaining approval from the ethics committee of the Graduate School of Sport and Health Science, Hosei University (2022_27).

2.2. Experimental design

Participants were randomly assigned to two groups (Groups A and B) using the RAND function in Excel (Microsoft), and the experiment was implemented for 2 experimental periods. The duration of each experiment is 15 days. Each experimental period consists of the generally training period (7 day), the tapering period (7 day), and the TT (1 day). After the first experiment was completed, a second experiment was implemented with a 2-week washout period.

In both experimental periods, Days 1 to 7 of the experiment, the "generally training period" was set up according to the "training during the competition period (weeks without competitions)" presented in the instructional manual[12] for junior high school students and other junior age groups. For all participants, the total mileage for the generally training period was set at 35.8 km based on the instructional manual[12] for junior high school students and other junior age groups. Days 8 to 14 of the experiments, in the "tapering period," two rates of reduction were set based on the mileage during the generally training period. During the tapering period, the rate of decrease in mileage varied by group. For the rate of reduction in mileage, the study adopted the "41%" the rate of reduction recommended as the optimal the rate of reduction for tapering based on the results of a meta-analysis[4] of general adult and the "21%" the rate of reduction, which showed a significant difference between performance. The running mileage in the recommended tapering in "41% rate of reduction tapering (recommended tapering)", calculated based on the total mileage of generally training period, resulted in 28.3 km. On the other hand, the mileage at the "21% rate of reduction tapering (slight tapering)", calculated from the total mileage during a typical training period.

The mileage in the main training was included in the analysis, while the mileage during the warm-up and cooling-down was excluded. On the 13 day of the experiments period (the 6 day of the tapering period), the participants were implemented two 1,000 m runs in the recommended tapering and one 1,000 m run in the slight tapering as high intensity training before TT. On the 15 day of the experiments period (the day following the end of the tapering period), participants competed in the 3,000 m competition as a TT.

In the first experimental period, Groups A and B were implemented the same training during the generally training period. During the tapering period, Group A was implemented tapering by reduced about 41% (recommended tapering) from mileage of the generally training period and Group B was implemented tapering by reduced about 21% (slight tapering) from mileage of the generally training period. In the second experimental period, Groups A and B were subjected to the same training during the general training period, but Group A was implemented with recommended tapering and Group B received slight tapering.

2.3 Assessment of 3,000 m running time

On the day following the end of the tapering period, the participants were participated in a 3,000 m at an official competition, and their time were measured by electric timing. The baseline time was defined as the personal best before each TT. The weather, temperature, and wind speed at the time of implementing the TT were recorded.

2.4 Assessment of autonomic nervous system activity during the tapering period

HRV was measured to assess autonomic activity during the tapering period. In both the first and second experiments, measurements were implemented the early morning hours of the "1 day of tapering period (day 8 of the entire experimental period)," "4 day of tapering (day 11 of the entire experimental period)," "7 day of tapering period (day 14 of the entire experimental period)," and "day of implementing TT (day 15 of the entire experimental period)" with the participants wearing a V 800 GPS SPORTS WATCH (Polar) on the participant's wrist and H10 HEART RATE SENSOR (Polar Electro Oy, Finland) on the participant's chest, and measurements were made for 5 minutes in a seated resting position. 3 minutes of data were used for the analysis, excluding 1 minute at the beginning of the measurement and 2 minutes before the end of the measurement[16]. The obtained data were corrected for noise using Kubios HRV Scientific 4.0 (kubios Oy, Finland), and time-domain analysis was performed to calculate RMSSD. The calculated RMSSD was logarithmically transformed to account for data distortion[31], and the logarithm of RMSSD (Ln RMSSD) was used as an index of parasympathetic activation in this study.

2.5 Assessment of psychological fatigue and tension

In order to assess psychological fatigue and tension during the tapering period, this study used the Profile of Mood State 2nd Edition (POMS2) for Youth[35]. POMS2 measurements were taken early in the morning on "day 1 of the taper period (day 8 of the total experimental period)," "day 4 of the taper period (day 11 of the total experimental period)," "day 7 of the taper period (day 14 of the total experimental period)," and "day 15 of the TT implementation (day 15 of the total experimental period). 35 questions were answered using a five-point scale: "Not at all (0 points)," "A little (1 point)," "Fairly (2 points)," "Quite a bit (3 points)," and "Very much (4 points). The scores were converted to T-scores using a conversion table. The respondents were asked to answer all questions, and only the "Fatigue" and "Tension" scales were used for analysis.

2.6 Assessment of ratings of perceived exertion on 3,000 m TT

The Japanese version[25] of the Ratings of Perceived Exertion (RPE) was used to assess perceived exercise intensity during implementing TT. The RPE is answered using a scale of 6 to 20. The RPE at 1,000 m, 2,000 m, and 3,000 m during implementing the TT was answered immediately after the TT.

2.7 Statistical analysis

R was used for statistical analysis. Nonparametric statistical methods were used because the number of participants in the analysis was small and a normal distribution was not assumed. In order to perform an analysis of variance on nonparametric data, an aligned rank transform[34] (ART) was performed on each data set.

A mixed-effects model was used to analyze the 3,000 m time, with the 3,000 m time before the tapering period and measured in the TT as dependent variables, the condition factor (two levels: recommended tapering and slight tapering), the time factor (two levels: before and after implementing the tapering period) as fixed effects, and individual differences of each participant as random effects.

The RPE during TT was analyzed using a mixed-effects model with the RPE during TT as the dependent variable, the condition factor (two levels: recommended tapering and slight tapering) and the time factor (three levels: at 1,000 m, 2,000 m, and 3,000 m) as fixed effects and individual differences for each participant as random effects.

In addition, 9 subjects who had no incomplete measurements for Ln RMSSD were included in the analysis. A mixed-effects model was used to analyze Ln RMSSD, Ln RMSSD as dependent variables, the condition factor (two levels: recommended tapering and slight tapering), the time factor (four levels: 1 day of tapering period, 4 day of tapering period, 7 day of tapering period, and day of implementing TT) as fixed effects, and individual differences of each participant as random effects.

"Fatigue" and "Tension" scale scores by measured the POMS2 was analyzed using a mixed-effects model with the scale scores as the dependent variable, the condition factor (two levels: recommended tapering and slight tapering) and the time factor (four levels: 1 day of tapering period, 4 day of tapering period, 7 day of tapering period, and day of implementing TT) as fixed effects and individual differences for each participant as random effects.

The change in mileage from the generally training period to the tapering period was analyzed using a mixed-effects model with the mileage in each period as the dependent variable, the condition factor (two levels: recommended tapering and slight tapering), the time factor (generally training period and tapering period) as fixed effects, and individual differences for each participant as random effects. When significant main effects and interactions were observed in the mixed-effects model analysis, post-hoc tests using the Tukey method were conducted.

Data are presented as mean ± standard deviation to two decimal places, but the statistic is presented to three decimal places. The statistical significance level was set at $\alpha = 0.05$.

3. Result

3.1 Assessment of 3,000 m running time and RPE

The weather conditions when all subjects performed the 3,000 m TT on day 7 of the first experimental period were sunny, with a temperature of 13.5 °C, humidity of 61%, and wind speed of 2.7 m/s. And, the weather conditions when all subjects performed the 3,000 m TT on day 7 of the second experimental period were sunny, with a temperature of 14.0° C, humidity of 18%, and wind speed of 7.1 m/s.

The times on the 3,000 m TT are shown in Table 1. The results of the mixed-effects model analysis showed no significant main effects or

Table1 The times on the 3,000 m TT.

		Before TT	Implementing TT	ANOVA				
				Effect	F	P	Partial η^2	Post hoc
3,000 mTT recoad (min / sec)	recommended tapering	10:20.85 ± 46.75	10:27.01 ± 42.21	Condition	0.030	0.864	0.001	–
				Time	2.412	0.130	0.068	–
	slight tapering	10:23.16 ± 47.47	10:26.13 ± 49.82	Condition × Time	0.271	0.606	0.008	–

Table2 The changes in RPE during the implementation of the 3,000 m TT.

		1,000 m	2,000 m	3,000 m	ANOVA				
					Effect	F	P	Partial η^2	Post hoc
RPE	recommended tapering	12.6 ± 3.2	16.0 ± 2.3	18.3 ± 2.6	Condition	2.103	0.153	0.037	—
					Time	48.230*	< 0.001	0.637	3,000m > 1,000m, 3,000m > 2,000m, 2,000m > 1,000m
	slight tapering	13.1 ± 2.9	16.9 ± 1.8	18.7 ± 1.8	Condition × Time	0.559	0.575	0.020	—

Note. *: $p < 0.05$

Table3 The changes in Ln RMSSD over the tapering period.

		1 day of tapering period	4 day of tapering period	7 day of tapering period	day of implementing TT	Anova				
						Effect	F	P	Partial η^2	Post hoc
Ln RMSSD	recommended tapering	4.07 ± 0.27	4.44 ± 0.97	3.89 ± 0.43	4.52 ± 0.98	Condition	4.853*	0.032	0.080	recommended tapering > slight tapering
						Time	4.623*	0.006	0.199	day of implementing TT > 7 day of tapering period
	slight tapering	3.88 ± 0.64	4.02 ± 0.58	3.69 ± 0.57	4.26 ± 0.74	Condition × Time	0.142	0.935	0.008	—

Note. *: $p < 0.05$

interactions.

The changes in RPE during the implementation of the 3,000 m TT are shown in Table 2. The results of the mixed effects model analysis showed a significant main effect on the time factor (F [2, 55] = 48.230, p < 0.001, partial η^2 = 0.637). The results of post-test showed significant differences between the 1,000 m and 2,000 m (p < 0.001), between the 1,000 m and 3,000 m (p < 0.001), and between the 2,000 m and 3,000 m (p < 0.001).

3.2 Assessment of autonomic nervous system activity during the tapering period

The changes in Ln RMSSD during the tapering period are presented in Table 3. The results of the mixed effects model analysis showed a significant main effect on the condition factor (F [1, 56] =4.853, p = 0.032, partial η^2 = 0.080). The results of post hoc analysis showed significant differences between recommended tapering and slight tapering (p = 0.032). A significant main effect on the time factor was found (F [3, 56] = 4.623, p = 0.005, partial η^2 = 0.199). The results of post hoc analysis showed significant difference was found between the 6 day of tapering and the day of implementing TT (p = 0.004).

3.3 Assessment of psychological fatigue and tension

Changes in the "fatigue" and "tension" scale score measured by the POMS2 during the tapering period are shown in Table 4.

For the "Fatigue" scale score, a mixed effects model analysis revealed a significant main effect on the condition factor (F [1, 77] = 5.574, p = 0.021, partial η^2 = 0.067). The results of post hoc analysis showed significant differences between recommended tapering and slight tapering (p =

Table4 The changes in “Fatigue” and “Tension” scale score over the tapering period.

		1 day of tapering period	4 day of tapering period	7 day of tapering period	day of implementing TT	Anova				
						Effect	*F*	*P*	*Partial η²*	Post hoc
Fatigue	recommended tapering	36.5 ± 3.8	37.6 ± 5.1	36.0 ± 3.1	34.7 ± 1.9	Condition	5.574*	0.021	0.067	recommneded tapering > slight tapering
						Time	4.005*	0.015	0.135	7 day, 4day, 1 day of tapering > day of implementing TT
	slight tapering	39.1 ± 6.6	37.3 ± 4.2	38.2 ± 3.6	35.0 ± 1.7	Condition × Time	0.173	0.326	0.044	–
Tension	recommended tapering	38.7 ± 2.8	38.2 ± 2.3	37.8 ± 2.3	42.4 ± 4.9	Condition	8.372*	0.005	0.098	recommended tapering > slight tapering
						Time	11.184*	<0.001	0.303	day of implementing TT > 7 day, 4 day, 1 day of tapering
	slihgt tapering	38.9 ± 3.0	38.7 ± 2.8	41.2 ± 4.8	43.6 ± 5.2	Condition × Time	0.142	0.149	0.067	–

Note. *: $p < 0.05$

0.021). Significant differences were also found on the time factor (F [3, 77] = 4.005, p = 0.015, partial η^2 = 0.135), and post hoc analysis showed significant differences between the 1 day of tapering period and the day of implementing TT (p = 0.027) and between the 6 day of tapering and the day of implementing TT (p = 0.020).

For the “Tension” scale score, a mixed effects model analysis revealed a significant main effect on the condition factor (F [1, 77] = 8.372, p = 0.005, partial η^2 = 0.098). The results of post hoc analysis showed significant differences between recommended tapering and slight tapering (p = 0.005). Significant differences were also found on the time factor (F [3, 77] = 11.184, p < 0.001, partial η^2 = 0.303), and post hoc analysis showed significant differences between the 1 day of tapering period and the day of implementing TT (p < 0.001) and between the 4 day of tapering period and the day of implementing TT (p < 0.001) and between the 6 day of tapering and the day of implementing TT (p = 0.009).

3.4 Change in mileage during the experimental period

Changes in the in mileage from the generally training period to the tapering period during the experimental period are shown in Table 5. The results of the mixed effects model analysis showed a significant main effect on the condition factor (F [1, 33] = 133.61, p < 0.001, η^2 = 0.802) and time factor (F [1, 33] = 134.32, p < 0.001, η^2 = 0.803). And, there was also a significant interaction (F [1, 33] = 132.80, p < 0.001, η^2 = 0.800) between condition and time factors. A simple main effect test showed that the generally training period mileage of the slight tapering was significantly larger than the tapering period mileage of the slight tapering (p < 0.001). The mileage during the tapering period of the slight tapering was significantly larger than that during the tapering period of the recommended tapering (p < 0.001). Furthermore, the mileage during the generally training period of the recommended tapering was significantly larger than the mileage during the tapering period of the recommended tapering (p < 0.001).

Table5 Change in mileage during the experimental period.

		Generally training period	tapering period	ANOVA				
				Effect	*F*	*P*	Partial η^2	Post hoc
Mileage (km)	recommended tapering	36.1 ± 0.4	**21.5 ± 0.4**	Condition	**133.61***	< 0.001	**0.802**	–
				Time	**134.32***	< 0.001	**0.802**	–
	slight tapering	36.4 ± 0.8	28.8 ± 0.7	Condition × Time	**132.80***	<0.001	**0.801**	the tapering period mileage of the slight tapering < the generally training period mileage of the slight tapering , tapering period of the slight tapering < the tapering period of the recommended tapering, the tapering period of the recommended tapering < the generally training period of the recommended tapering

Note. *: $p < 0.05$

4. Discussion

4.1 Effect on 3,000 m running time

The results of this study suggest that in the junior high school student runners, differences in the rate of reduction in mileage during the tapering period may have a small effect on the 3,000 m running time. In the past, a meta-analysis of general adults[4] reported that tapering strategies that reduced mileage by 41-60% were beneficial. And, Houmard et al.[11] reported that 5 km running times were maintained before tapering when tapering was used to reduce mileage by 70% in general adult subjects. Moreover, Witting et al.[33] reported that fatigue scale measured by POMS was reduced and 5 km running times were maintained before tapering when tapering was performed with a 70% reduction in mileage in general adult subjects. On the other hand, there was no significant difference in 3,000 m running times before and after tapering in the present study, whether the mileage was reduced by about 20% or about 40%, suggesting that the two types of tapering in the present study may suppress the de-training effect. Therefore, it is possible that junior high school student runners, whose daily mileage is low, may be able to maintain their performance from pre-tapering even with a small rate of reduction in mileage, without a large rate of reduction in mileage as in the general adult subjects [4, 12, 33]. This was similar to a study of junior high school student runners[23], which reported that 3,000 m running times were maintained even when the running distance was reduced by about 20%.

The reasons for these results may be influenced by the training situation specific to the junior high school student runners. In the present study, the mileage was set at 35.8 km per week in the generally training period, 28.3 km per week in the tapering training period with a slight tapering, and 21.1 km per week in the recommended tapering period. On the other hand, in the general adult subjects and elite runners, there are some runners with high weekly mileage who reach about 200 km per week[8], and applying the rate of reduction in mileage during the tapering period used in this study, the mileage is about 120 km per week in the slight tapering and about 160 km per week in the recommended tapering. In the way, daily mileage varies greatly between adults and junior high school student runners. And, it is assumed that the state of accumulated fatigue is also different. Therefore, it is assumed that the significance of tapering differs greatly. In the future, it is possible that new findings will be obtained by examining the effects of differences in mileage on training during the tapering period.

Therefore, in junior high school student runners, a strategy with a small rate of reduction in mileage may be an appropriate tapering strategy. In general, it is known that a large rate of reduction in mileage during the tapering period improves performance[4]. However, in the present study, there was no decrease in performance during the tapering period, even with a small rate of reduction in mileage. And, Obata et al.[23] also reported that the 3,000 m running time was maintained while decreasing fatigue even at a rate of about 20% decrease in mileage. Therefore, for junior high school student runners, who train differently than general adult subjects, there is a strong need to determine an appropriate rate of reduction in mileage by comprehensively considering the training situation and psychological fatigue of each individual runners, rather than situation decreasing mileage significantly during the tapering period.

4.2 Effects on parasympathetic nerve activity

The results suggest that tapering may activate parasympathetic nerve activity. It has been previously reported that Ln RMSSD, which assesses parasympathetic activity, increases with decreasing mileage in tapering[3], and in this study, it was significantly increased from the last day of tapering to the day of TT, and recommended tapering was higher levels. In addition, the level of activity of parasympathetic function in the period immediately before a competition has been used to confirm the condition[16], and it has been reported that performance in a competition improves when parasympathetic function is elevated[16), 31]. Therefore, it can be inferred that in the recommended tapering with higher levels of Ln RMSSD compared to the slight tapering, the runners were able to implement the competition with better autonomic nervous system conditions.

On the other hand, tension toward the competition may interfere with the activation of parasympathetic activity, and the "tension" scale score measured by POMS2 was higher in the slight tapering compared to the recommended tapering. In the past, Plews et al.[26] reported a case in which RMSSD decreased before a competition in elite athletes due to the stress of competition. It has also been reported that RMSSD changes depending on the importance of the competition[31] and that RMSSD decreases in important competitions[2]. Furthermore, tension scores measured by the POMS have been reported to increase prior to a competition in response to competition anxiety[24]. In light of the results of the above previous studies, it is highly likely that anxiety, stress and tension toward the competition affect parasympathetic nervous activity. Therefore, it is inferred that tension scores were higher and Ln RMSSD was lower compared to the recommended tapering, because the slight tapering failed to decrease anxiety and stress toward TT compared to the recommended tapering.

It was also suggested that parasympathetic activation may be prevented on the day following the implementation of the high-intensity training. In the present study, Ln RMSSD was higher on the last day of tapering. The reason for these results may be related to the fact that the high-intensity training was conducted the day before the last day of tapering. It has been reported that it takes at least 48 hours for parasympathetic function to recover after high-intensity training[30]. In light of the results of this study and previous research[30], it is highly likely that parasympathetic activation will decrease the day after high-intensity training. In addition, since it has been suggested that performance improves when parasympathetic function is increased in the period immediately before a competition[16], caution should be exercised when conducting high-intensity training on the day before a competition[22], which is widely practiced in Japan, and there is room to consider how such training should be conducted.

4.3 Effects on psychological fatigue

The results also suggest that psychological fatigue may be reduced by tapering in the junior high school student runners. In the past, Witting et al.[33] reported a decrease in fatigue scale scores measured by POMS as a result of tapering in general adult subjects with a 70% decrease in mileage. Although the rate of reduction in mileage was less than that reported in previous studies, the results of the present study showed that fatigue scale scores measured by POMS2 decreased from the first day of tapering to the day of TT implementation, and were smaller with the recommended tapering. Thus, a greater decrease in mileage may result in a greater reduction in psychological fatigue.

However, in junior high school student runners, who are less fatigued, it is questionable whether the reduction in psychological fatigue observed in this study is beneficial to their performance. The results of this study showed no improvement in the 3,000 m running time. And, the highest fatigue scale score measured by POMS2 is 77.0 points and the lowest is 33.0 points, with higher scores indicating greater psychological fatigue. In this study, the scores measured on the first day of tapering were low, 36.5 points in recommended tapering and 39.1 points in slight tapering. Since this study was implemented from late March to late April, before the start of the competition season, there may have been less psychological fatigue. Therefore, it is possible that the subjects in this study were not in a state of psychological fatigue that would affect the 3,000 m running time. In the future, new findings may be obtained by examining the effects of tapering on psychological fatigue in junior high school student runners, where psychological fatigue is high.

4.4 Limitations of the Study and Future Prospects

However, this study has several limitations. First, in both conditions used in this study, although a reduction in psychological fatigue and activation of the parasympathetic nervous system were observed on the day of implementing TT, it did not lead to an improvement in the 3,000 m running time. In this study, the wind speeds during the first and second experimental periods were 2.7 m/s and 7.7 m/s, respectively, a large difference. In outdoor competitions, it is difficult to control the weather conditions, and competition are often held under bad weather condition. Under such conditions, even if optimal tapering could be implemented, it may not necessarily lead to improved performance. Therefore, the overall ranking in the competition, physiological and psychological conditions, and other factors should be taken into consideration when evaluating the goodness or badness of tapering.

Another limitation of this study, participants who no other sports, only training for middle- and long- distance running were included. In the past, it has been reported that many junior high school students are active in other clubs as well[21, 22), 32)]. The findings of this study may not be applicable to these individuals who are not implementing training in middle- and long-distance events on a routine basis. In the future, new findings may be obtained by examining training during the tapering period for participants who are also active in other clubs and track and field clubs.

In addition, this study only included training interventions and not daily life interventions. Part of this experimental period took place during the period of implementing classes, and there is a small possibility that events in school life may have affected the psychological indexes measured in this study and the level of parasympathetic nervous system activity. In the future, the interpretation of the results may become easier by conducting the survey in combination with interview surveys.

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