UNIVERSITI SAINS MALAYSIA
GERAN PENYELIDIKAN UNIVERSITI PENYELIDIKAN
LAPORAN AKHIR

ENHANCING PHYSIOLOGICAL PSYCHOLOGICAL AND TIME TRIAL PERFORMANCE OUTCOMES USING TAPERING TECHNIQUE AMONG JUNIOR CYCLISTS

PENYELIDIK

PROF. MADYA DR. HAIRUL ANUAR HASHIM

PENYELIDIK BERSAMA

ASSOC. PROF. DR. OLEKSANDRA KRASILSHCHIKOV
DR. MOHD NIDZAM BIN MAT JAWIS

2016

Project Code :
(for RCMO use only)

UNIVERSITI SAINS MALAYSIA

RU GRANT FINAL REPORT FORM

Please email a softcopy of this report to rcmo@usm.my

A PROJECT DETAILS

i Title of Research: **Enhancing Physiological, Psychological And Time Trial Performance Outcomes Using Tapering Technique Among Junior Cyclists**

ii

iii Name of Research Leader: ASSOC. PROF. DR. HAIRUL ANUAR BIN HASHIM

iv Name of Co-Researcher:

1. ASSOC. PROF. DR. OLEKSANDR KRASILSHCHIKOV
2. DR. MOHD NIDZAM BIN MAT JAWIS
3.

v Duration of this research:

a) **Start Date** : **15 JANUARY 2014**

b) **Completion Date** : **14 JANUARY 2016**

c) **Duration** : **24 MONTH**

d) **Revised Date** (*if any*) : **14 JULY 2016**

B ABSTRACT OF RESEARCH

(An abstract of between 100 and 200 words must be prepared in Bahasa Malaysia and in English. This abstract will be included in the Report of the Research and Innovation Section at a later date as a means of presenting the project findings of the researcher/s to the University and the community at large)

Attached

C	BUDGET & EXPENDITURE
i	*# Please attach final account statement (eStatement) to indicate the project expenditure*
ii	**Equipment Purchased Under Vot 35000**

No.	Name of Equipment	Amount (RM)	Location	Status
	None			

 # Please attach the Asset/Inventory Return Form (Borang Penyerahan Aset/Inventori) – Appendix 1

D	RESEARCH ACHIEVEMENTS
i	**Project Objectives** *(as stated/approved in the project proposal)*

No.	Project Objectives	Achievement
1	To investigate the effects of modified exponential taper with increase load during the final three days of taper on physiological outcomes (VO2max, Wmax, Maximal heart rate, and RPE) and blood profile (hemoglobin, hematocrit, blood lactate, creatine kinase, lactate dehydrogenase, cortisol and ferritin).	The results showed that modified exponential taper was better than no taper group on VO2max, Wmax, Maximal heart rate, and RPE) and blood profile (hemoglobin, hematocrit, blood lactate, creatine kinase, lactate dehydrogenase, cortisol. However, no different between modified exponential taper and normal exponential taper group on these parameters.

2	To investigate the effects of modified exponential taper with increase load during the final three days of taper on psychological outcomes (tension, anger, depression, confusion, fatigue and vigor).	The results showed that modified exponential taper was better than no taper group fatigue and vigor. However, no different between modified exponential taper and normal exponential taper group on these parameters.
3	To investigate the effects of modified exponential taper with increase load during the final three days of taper on performance outcomes (20 km time trial).	The results showed that modified exponential taper was better than no taper group on (20 km time trial). However, no different between modified exponential taper and normal exponential taper group on these parameters.

ii **Research Output**

a) Publications in ISI Web of Science/Scopus

No.	**Publication** (authors,title,journal,year,volume,pages,etc.)	**Status of Publication** (published/accepted/ under review)
1.	**A.Ishak, H.A. Hashim, O. Krasilshchikov (2016). The effects of modified exponential tapering techniques on perceived exertion, heart rate, time trial performance,$V0_2$max and power output among highly trained junior cyclists. Journal of Sports Medicine & Physical Fitness. Impact Factor:0.79.**	Published
2.	**Changes in Mood States and Cortisol Level And Cycling Performance Following Modified And Normal Taper Among Elite Junior Cyclist. Journal of Sports Medicine & Physical Fitness**	Under Review

b) Publications in Other Journals

No.	**Publication** (authors,title,journal,year,volume,pages,etc.)	**Status of Publication** (published/accepted/ under review)

c) Other Publications
(book,chapters in book,monograph,magazine,etc.)

No.	**Publication** (authors,title,journal,year,volume,pages,etc.)	**Status of Publication** (published/accepted/ under review)

d) **Conference Proceeding**

No.	Conference (conference name,date,place)	Title of Abstract/Article	Level (International/National)
1	**10th International Sports Science Conference, 25-27 August 2014, Perdana Hotel, Kota Bharu, Kelantan, Malaysia.**	**The Effects of 2 Weeks Exponential Taper on Selected Physiological and Biochemical Parameters among Junior Cyclists.**	**International**

 # Please attach a full copy of the publication/proceeding listed above

iii **Other Research Ouput/Impact From This Project**
(patent, products, awards, copyright, external grant, networking, etc.)

This project has strengthen the networking between Exercise and Sports Science Programme with Majlis Sukan Negeri Perlis and Majlis Sukan Negeri Kelantan.

E HUMAN CAPITAL DEVELOPMENT

a) **Graduated Human Capital**

Student	Nationality (No.)		Name
	National	International	
PhD	✓		1.Asmadi bin Ishak 2.
MSc	✓		1.Nur Hidayah binti Noordin 2.
Undergraduate			1. 2.

b) **On-going Human Capital**

Student	Nationality (No.)		Name
	National	International	
PhD			1. 2.
MSc			1.Nurul Aimie Jusoh 2.
Undergraduate			1. 2.

c) **Others Human Capital**

Student	Nationality (No.)		Name
	National	International	
Post Doctoral Fellow			1. 2.
Research Officer			1. 2.
Research Assistant			1. 2.
Others (.....................)			1. 2.

F COMPREHENSIVE TECHNICAL REPORT

Applicants are required to prepare a comprehensive technical report explaining the project. The following format should be used (this report must be attached separately): **COMPREHENSIVE TECNICAL REPORT IS ATTACHED**

- Introduction
- Objectives
- Methods
- Results
- Discussion
- Conclusion and Suggestion
- Acknowledgements
- References

G PROBLEMS/CONSTRAINTS/CHALLENGES IF ANY

(Please provide issues arising from the project and how they were resolved)

The project run smoothly. However, a glitch in EFAS system has resulted in the grant being overspent.

H RECOMMENDATION

(Please provide recommendations that can be used to improve the delivery of information, grant management, guidelines and policy, etc.)

To speed up the grant and ethical approval process

I	COMMENTS, IF ANY/ENDORSEMENT BY PTJ'S RESEARCH COMMITTEE
	Pencapaian objektif memuaskan. Penghasilan output baik telah menghasilkan satu penerbitan, 2 pelajar siswazah (1 phd & 1 msc) juga memperkasa jaringan. 1 lg penerbitan dlm proses dan f/up keatas penerbitan akan dilakukan. Diperakui utk tutup.

UserCode: JPNP / USMKCKLIVE / PPSP

Program Code: Votebook9100

Current Program : Votebook (Header)

Current Date : 07/11/2016 10:00:14 AM

Version: 15.124, Last Updated at 09/08/2016

DB: 13.00, 9/18/2010 VB: 13.01, 3/14/2011

Switch Language : English /Malay

Wildcard : eg. Like 100%, Like 10%1, Like %1

Element 1: %1001

Element 2: %

Element 4: PPSP

Element 5: %812134

Year: 2016

Detail Excel	Budget Rule	Budget Control	Account Description	Budget Account Code	Roll over	Budget	Cash Received	Advanced	Commit	Actual	Available	Percentage
	46	T	Projek Kumpulan Wang Uni Penyelidikan	1001.111.0.PPSP.812134	33,839.90	0.00	0.00	0.00	0.00	0.00	33,839.90	0.00%
	46	T	Projek Kumpulan Wang Uni Penyelidikan	1001.114.0.PPSP.812134	-1,077.31	0.00	0.00	0.00	0.00	91.54	-1,168.85	0.00%
	46	T	SubTotal		32,762.59	0.00	0.00	0.00	0.00	91.54	32,671.05	0.00%
	47	T	Projek Kumpulan Wang Uni Penyelidikan	1001.221.0.PPSP.812134	4,760.50	0.00	0.00	0.00	0.00	0.00	4,760.50	0.00%
	47	-	Projek Kumpulan Wang Uni Penyelidikan	1001.223.0.PPSP.812134	600.00	0.00	0.00	0.00	0.00	0.00	600.00	0.00%
	47	-	Projek Kumpulan Wang Uni Penyelidikan	1001.224.0.PPSP.812134	2,000.00	0.00	0.00	0.00	0.00	0.00	2,000.00	0.00%
	47	-	Projek Kumpulan Wang Uni Penyelidikan	1001.225.0.PPSP.812134	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00%
	47	-	Projek Kumpulan Wang Uni Penyelidikan	1001.227.0.PPSP.812134	-29,558.00	0.00	0.00	0.00	0.00	37,230.00	-66,788.00	0.00%
	47	-	Projek Kumpulan Wang Uni Penyelidikan	1001.228.0.PPSP.812134	5,000.00	0.00	0.00	0.00	0.00	0.00	5,000.00	0.00%
	47	-	Projek Kumpulan Wang Uni Penyelidikan	1001.229.0.PPSP.812134	-7,899.11	0.00	0.00	0.00	0.00	6,900.00	-14,799.11	0.00%
	47	T	SubTotal		-25,096.61	0.00	0.00	0.00	0.00	44,130.00	-69,226.61	0.00%
	48	-	Projek Kumpulan Wang Uni Penyelidikan	1001.335.0.PPSP.812134	32,000.00	0.00	0.00	0.00	0.00	0.00	32,000.00	0.00%
	48	T	SubTotal		32,000.00	0.00	0.00	0.00	0.00	0.00	32,000.00	0.00%
	50	T	Projek Kumpulan Wang Uni Penyelidikan	1001.552.0.PPSP.812134	0.00	0.00	0.00	0.00	469.26	1,086.18	-1,555.44	0.00%
	50	T	SubTotal		0.00	0.00	0.00	0.00	469.26	1,086.18	-1,555.44	0.00%
	9999		GrandTotal		39,665.98	0.00	0.00	0.00	469.26	45,307.72	-6,111.00	0.00%

RU GRANT FINAL REPORT CHECKLIST

Please use this checklist to self-assess your report before submitting to RCMO.
Checklist should accompany the report.

NO.	ITEM	PLEASE CHECK (✓)		
		PI	JKPTJ	RCMO
1	Completed Final Report Form	✓		✓
2	Project Financial Account Statement (e-Statement)	✓		
3	Asset/Inventory Return Form *(Borang Penyerahan Aset/Inventori)*	✓		✓
4	A copy of the publications/proceedings listed in Section D(ii) (Research Output)	✓		✓
5	Comprehensive Technical Report	✓		✓
6	Other supporting documents, if any			
7	Project Leader's Signature	✓		✓
8	Endorsement of PTJ's Evaluation Committee			✓
9	Endorsement of Dean/ Director of PTJ's			✓

Appendix 1

UNIVERSITI SAINS MALAYSIA

BORANG PENYERAHAN ASET / INVENTORI (Tiada Pembelian Aset)

==

A. BUTIR PENYELIDIK

1. NAMA PENYELIDIK :..
2. NO STAF :..
3. PTJ :..
4. KOD PROJEK :..
5. TARIKH TAMAT PENYELIDIKAN :..

B. MAKLUMAT ASET / INVENTORI

BIL	KETERANGAN ASET	NO HARTA	NO. SIRI	HARGA (RM)
	— NIL —	—		

C. PERAKUAN PENYERAHAN

Saya dengan ini menyerahkan aset/ inventori seperti butiran B di atas kepada pihak Universiti:

....

( ) Tarikh:

D. PERAKUAN PENERIMAAN

Saya telah memeriksa dan menyemak setiap alatan dan didapati :

☐ Lengkap
☐ Rosak
☐ Hilang : Nyatakan..
☐ Lain-lain : Nyatakan ....

Diperakukan Oleh :

....

Tandatangan Pegawai Aset PTJ

Nama :..
Tarikh :..

***Nota :** Sesalinan borang yang telah lengkap perlulah dikemukakan kepada Unit Pengurusan Harta, Jabatan Bendahari dan Pejabat RCMO untuk tujuan rekod.

ATTACHMENT

OPTIMIZING PHYSIOLOGICAL, PSYCHOLOGICAL AND PERFORMANCE OUTCOMES USING TAPERING TECHNIQUES AMONG JUNIOR CYCLISTS

ABSTRACT (English)

The aim of this study was to investigate the effects of increased training loads during the final three days of taper using modified exponential taper on physiological, psychological and performance outcomes among junior cyclists. This study involved a pre- and post-experimental design with a control group and two experimental groups (modified exponential taper and normal exponential taper). Twenty one junior male cyclists were recruited and 19 subjects (Mean age = 16.95± 0.8years) completed the whole study protocol. Participants were matched according to a baseline VO_{2max} value and they were assigned into either normal exponential taper (NET), modified exponential taper (MET) and control groups (CON). Both experimental groups underwent three months of progressive endurance training followed by two weeks of taper, while the control group continued their endurance training until the end of the study period. All parameters were measured at baseline, pre-taper and post taper. The results of the Mixed Factorial Analysis of Variance (ANOVA) revealed significant interactions between experimental groups across the measurement sessions for maximum oxygen consumption (VO_{2max}), maximum power output (W_{max}), maximum heart rate (HR_{max}), rating perceive of exertion (RPE), hemoglobin (Hg), hematocrit (Hct), lactate (Lac), creatine kinase (CK), lactate dehydrogenase (LDH), cortisol, fatigue and vigor. No significant interactions were observed for ferritin concentration value, anger, tension, depression and confusion scores. The results of post–hoc analysis revealed that both experimental groups (NET and MET) showed significantly higher values in VO_{2max}, W_{max}, RPE scores, Hg concentration values, Hct concentration value and Lac concentration value and vigor scores compared to the control group. Furthermore, the results of post-hoc analysis showed that the experimental groups (NET and MET) had significantly lower HR_{max}, CK, LDH, cortisol concentration values and fatigue scores compared to the control group. The result also revealed that the experimental groups had significantly faster time in the 20 km time trial compared to control group at post taper. However, no significant differences were observed between the MET and NET groups. It is concluded that the MET and NET are equally effective in optimizing the physiological, psychological and performance outcomes among junior cyclists.

MENGOPTIMUMKAN HASIL FISILOGIKAL, PSIKOLOGIKAL DAN PRESTASI DENGAN MENGGUNAKAN TEKNIK TAPER DIKALANGAN PELUMBA BERBASIKAL REMAJA

ABSTRAK (Bahasa Malaysia)

Tujuan kajian ini dijalankan adalah untuk mengkaji kesan peningkatan beban latihan dalam tiga hari terakhir fasa taper menggunakan protokol taper eksponen ke atas pemboleh ubah fisiologi, psikologi dan ujian masa 20KM dalam kalangan pelumba basikal remaja. Kajian ini melibatkan kumpulan kawalan dan dua kumpulan eksperimental iaitu kumpulan taper eksponen yang telah diubah suai dan kumpulan taper eksponen biasa. Dua puluh satu pelumba basikal remaja lelaki terlibat dalam kajian ini dan sembilan belas (19) peserta (purata umur = 16.95 $\pm$ 0.8 tahun) menamatkan kajian sehingga ke peringkat akhir. Peserta dipadankan berdasarkan nilai pengambilan oksigen maksimum (VO_{2max}) dari pengukuran awal dan dibahagikan kepada tiga kumpulan; taper eksponen biasa (NET), taper eksponen yang telah diubah suai (MET) dan kumpulan kawalan (CON). Kedua-dua kumpulan eksperimental menjalani latihan kecergasan berbentuk progresif selama tiga bulan diikuti dengan dua minggu latihan taper. Kumpulan kawalan meneruskan latihan kecergasan sehingga ke akhir tempoh kajian. Kesemua parameter diukur pada pengukuran awal, pra-taper dan pasca-taper. Hasil analisis variance *(ANOVA)* menunjukkan terdapat interaksi yang signifikan antara kumpulan eksperimental dengan kumpulan kawalan merentasi masa pengukuran untuk pemboleh ubah VO_{2max}, keluaran kuasa maksimum (W_{max}), kadar denyutan jantung maksimum (HR_{max}), *rating perceive of exertion* (RPE), hemoglobin (Hg), hematokrit (Hct), laktat (Lac), kreatina kinase (CK), laktat dehidrogenase (LDH), kortisol, kelesuan and semangat. Keputusan analisis post-hoc menunjukkan kedua-dua kumpulan eksperimental (NET dan MET) menunjukkan nilai VO_{2max}, W_{max}, skor RPE, kepekatan Hg, Hct, Lac dan vigor yang tinggi berbanding kumpulan kawalan. Sebagai tambahan, keputusan ujian post-hoc menunjukkan kumpulan eksperimen (NET dan MET) mempunyai nilai HR_{max}, CK, LDH, dan kepekatan kortisol and skor kelesuan yang signifikan rendah berbanding kumpulan kawalan. Keputusan kajian pasca taper menunjukkan kumpulan eksperimental mempunyai masa yang lebih pantas dalam ujian masa 20 km berbanding kumpulan kawalan. Walau bagaimanapun, tiada perbezaan yang signifikan ditunjukkan di antara kumpulan MET dan NET dalam kesemua parameter yang diukur. Sebagai kesimpulan, kedua –dua jenis taper (MET dan NET) mempunyai kesan yang sama untuk mengoptimumkan hasil prestasi, fisiologi dan psikologi dalam kalangan pelumba basikal remaja.

Online version at http://www.minervamedica.it

The Journal of Sports Medicine and Physical Fitness 2016 September;56(9):961-7

ORIGINAL ARTICLE
EXERCISE PHYSIOLOGY AND BIOMECHANICS

The effects of modified exponential tapering technique on perceived exertion, heart rate, time trial performance, VO_{2max} and power output among highly trained junior cyclists

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ABSTRACT

BACKGROUND: The present study investigated the effects of a 2-week modified exponential taper on physiological adaptation and time trial performance among junior cyclists.
METHODS: Participants (N.=27) with the mean age of 16.95±0.8 years, height of 165.6±6.1 cm and weight of 54.19±8.1 kg were matched into either modified exponential taper (N.=7), normal exponential taper (N.=7), or control (N.=7) groups using their initial VO_{2max} values. Both experimental groups followed a 12-week progressive endurance training program and subsequently, a 2-week tapering phase. A simulated 20-km time trial performance along with VO_{2max}, power output, heart rate and rating of perceived exertion were measured at baseline, pre and post-taper. One way ANOVA was used to analyze the difference between groups before the start of the intervention while mixed factorial ANOVA was used to analyze the difference between groups across measurement sessions. When homogeneity assumption was violated, the Greenhouse-Geisser Value was used for the corrected values of the degrees of freedom for the within subject factor the analysis.
RESULTS: Significant interactions between experimental groups and testing sessions were found in VO_{2max} (F=6.67, df=4, P<0.05), power output (F=5.02, df=4, P<0.05), heart rate (F=10.87, df=2.51, P<0.05) rating of perceived exertion (F=13.04, df=4, P<0.05) and 20KM time trial (F=4.64, df=2.63, P<0.05). *Post-hoc* analysis revealed that both types of taper exhibited positive effects compared to the non-taper condition in the measured performance markers at post-taper while no different were found between the two taper groups.
CONCLUSIONS: It was concluded that both taper protocols successfully inducing physiological adaptations among the junior cyclists by reducing the volume and maintaining the intensity of training.

(*Cite this article as:* Ishak A, Hashim HA, Krasilshchikov O. The effects of modified exponential tapering technique on perceived exertion, heart rate, time trial performance, VO_{2max} and power output among highly trained junior cyclists. J Sports Med Phys Fitness 2016;56:961-7)

Key words: Human physical conditioning - Cool-down exercise - Athletes.

Fatigue has been found as a single most influential factors affecting performance.[1] In order to minimize fatigue and maximize performance, several training strategies have been proposed such as taper.[2, 3] The underlying principle of taper is the manipulation of training volume, intensity, frequency, and duration.[4-6] For example, it has been suggested that training intensity during the tapering periods should be maintained at 70-90% of maximum heart rate.[6, 7] If the training intensity is reduced below 70%, some of the training induced adaptation may be lost and lead to suboptimal performance.[8] In term of the training volume, a reduction of 40-60% has been shown to retain or slightly improving training adaptation.[8, 9] Moreover, taper duration of approximately 14 days has been suggested as an optimal duration.[9-11]

Manipulation of these training variables has been used as the basis for various taper protocols such as non-progressive taper (*e.g.*, step taper) and progressive taper (*e.g.*, linear and exponential taper).[9, 11] While taper generally produces positive outcomes, a meta analytic study conducted by Bosquet *et al.*,[9] showed that progressive tapering technique such as exponential taper has more pronounced positive impacts than non-progressive taper technique such as step taper. Indeed, a study by Banister *et al.*[12] for example has shown that an exponential taper is superior when compared to a step taper. Moreover, Bosquet *et al.*[9] observed performance gain when training volume was reduced exponentially by 41-60% over 11-14 days with no alterations made to training intensity or frequency.

Bosquet *et al.*[9] speculates that modified tapering, which involved a planned increase of training load during the final days prior to the competition may be particularly beneficial to athletes such as cyclists. This speculation has been examined in a computer simulation study, which has revealed a positive outcome.[13] However, to our knowledge, no actual experimental studies that have been conducted to empirically test this computer simulation study. Moreover, taper literature seems to focus on elite athletes and limited studies have been done to examine the effect of taper among junior level athletes.

Therefore, the main purpose of the present study was to investigate the effects of 2-week modified exponential taper on perceived exertion, 20-km time trial performance, VO_{2max} and power output among regularly trained junior cyclists. It was expected that modified exponential taper would produce better outcomes than normal exponential taper and no taper conditions.

Materials and methods

Twenty seven male junior cyclists with the mean age of 16.9±0.8 years, height (165.6±6.1 cm), weight (54.1±8.1 kg), BMI (19.7±2.4 kg/m^2) and fat percentage of 20.0±4.0% participated in this study. They were matched into three groups using their initial VO_{2max} values. These groups were then randomly assigned to either the modified exponential taper (N.=9), normal exponential taper (N.=9), or the control group (N.=9). Prior to period of the study, the participants had trained regularly for five days a week for at least one year. Informed written consent form was obtained from all participants and their parents/guardians, and the study protocol was approved by the Human Ethics Committee of the Universiti Sains Malaysia.

The experimental protocols consisted of a 12-week progressive endurance training program and subsequently, a 2-week tapering phase. Three measurement sessions were conducted before and after the 12-week progressive endurance training (baseline and pre-taper) and after the 2-week tapering phase (post-taper).

Testing protocol

All participants performed a graded incremental test to exhaustion on an electromagnetically brake cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands) to determine maximal oxygen uptake (VO_{2max}) and power output (watt) at baseline measure, pre-taper and post-taper programs. For the graded incremental test, an initial load of 50 W was set and was progressively increased by 16W every one minute until exhaustion. Metabolic measurement system (Sensor Medic, Homestead, FL, USA) was used to collect and analyze the expired gas by open circuit spirometry. Gas exchange variables were monitored in an average of 20-s intervals. The gas analyzer was calibrated with primary standard gases (16.0% O_2, 4.0% CO_2) before and after the test. Heart rate was monitored continuously by using Polar heart rate monitor (Polar Electro, Kempele, Finland) and was recorded in a 10-second interval.

A simulated 20-km time trial was conducted at pre and post taper in order to evaluate the change in the physiological adaptations and time trial performance following each taper protocol. The same bicycle aluminum road bike (Trek Bicycle Corp., Waterloo, WI, USA) mounted on a jet fluid trainer cycling roller (CycleOps, USA) was used throughout the experiment. The air pressure of the bicycle tires was checked before and after the taper to ensure that maximum pressure was maintained. Cyclo computer wireless (CatEye Corp., Tokyo, Japan) was used to record the speed, revolution per minute and distance covered. Completion time was recorded using digital timer (Seiko, Tokyo, Japan). The room temperature (25 °C) and humidity (70%) was also standardized throughout the test.

The stimulated 20-km time trial began with a 15-minute warm up cycling at 50% of the participants' VO_{2max}. During the 20-km time trial ride, no performance feedback was provided to the cyclists at any time. Respiratory gas exchange responses (20-s interval) were monitored for 3 minutes every 5-km interval during the simulated ride. Heart rate was recorded continuously throughout the 20-km time trial using polar heart rate monitor (Polar Electro). Rating of perceived exertion (RPE) was also taken for every 5 km interval using the Borg 6-20 Scale.[11]

Progressive endurance training program

The training program consisted of a 12-week progressive endurance training program and subsequently, a 2-week tapering phase. The participants trained under the supervision of a state level cycling coach for a period 12 weeks, which was divided into three distinct phases.[14] The first phase consisted of high-volume, low-intensity protocols at intensity 60-70% of HR_{max} (maximal heart rate) for 60-180 minutes, 6 days a week, for three weeks.[15]

The second phase consisted of moderate intensity and moderate volume protocols at 75-85% of HR_{max} for 90-150 minutes, 6 days/week for the five weeks.[16] The third phase of the training program consisted of high intensity, low volume protocols where training intensity is maintained 85-95% of HR_{max} for 60-90 minutes, 5 days a week for four weeks.[15, 16] Throughout the duration of the training session, the participants' heart rate was monitored using a heart rate monitor (Polar Electro). Each participant was given a training log to record duration of training, distance covered, maximal and average heart rate. Preceding and during taper, the training loads was quantified using perceived exertion (RPE) method as suggested by Foster *et al.*[17]

Tapering protocols

After the completion in the 12-week progressive endurance training program, both experimental groups engaged in either modified exponential or normal exponential taper programs for 2-weeks. While, the control group continue the routine training until end the data collection phase. During tapering training, the participants trained under the supervision of a state level cycling coach and closely monitored by the researcher. Specifically, the researcher monitored subjects' training program adherence and ensuring that the prescribed training intensity and volume was followed. The magnitude of the reduction in the training load (volume) was determined from the average hours of training of the three weeks preceding the taper.

The normal exponential taper protocol consisted of progressive reduction of training hours to 40-70% of the pre-taper value (*i.e.*, 40%, 50%, R, 65%, 50%, 60%, R, 50%, 70%, Rest (R), 55%, 60%, 70%, and R during tapering days 1-14, respectively). Whereas, in the modified exponential taper protocol, the progressive reduction of training hours were accompanied by the final three days increase in training load from 40-70% of the pre-taper value (*i.e.*, 40%, 50%, R, 65%, 50%, 60%, R, 50%, 70%, R, 60%, 50%, 40% and R during tapering days 1-14, respectively).[12]

Throughout the duration of the periodized endurance training and the 14-day tapering phases, participants were neither provided with any additional supplements nor were they provided with any. Furthermore, participants were required to fill up food intake diary for three days prior to each measurement session to rule out nutritional effects on the measured parameters.

Statistical analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (IBM SPSS version 22). One way ANOVA was used to analyze the difference between groups before the start of the intervention in VO_{2max}, BMI and fat percentage while mixed factorial ANOVA was used to analyze the difference between groups across measurement sessions. When homogeneity assumption was violated, Greenhouse-Geisser Value was used for the corrected values of the degrees of freedom for the within subject factor the analysis. The level of significant value was set at $P<0.05$. Prior to the main analysis, the data were checked for normality, outliers, and missing values. Skewness and kurtosis are within acceptable range while no outliers above Z-score of ±3.0 were present. Furthermore, no missing values were present.

Results

Descriptive statistics of the primary variables are presented in Table I. The results of one-way ANOVA revealed no significant different between the groups in VO_{2max} (F=0.012, df=2, P>0.05), BMI (F=1.45, df=2, P>0.05), and fat percentage (F=0.79, df=2, P>0.05) before the start of the intervention. The results of mixed factorial ANOVA indicated significant interactions between the groups across the measurement session for all of the measured variables (Table II). Significant interactions were found for VO_{2max} (F=6.67, df=4, P<0.05), peak power output (F=5.02, df=4, P<0.05), heart rate (F=10.87, df=2.51, P<0.05) rating of perceived exer-

TABLE I.—*Descriptive statistics of primary variables (mean ± SD).*

Variables	Baseline	Pre-taper	Post-taper
VO_{2max} (mL/kg/min)			
Control group	64.70±9.99	63.22±9.05	65.50±7.38
NET group	64.44±2.34	65.47±2.27	75.27±2.50
MET group	65.02±7.66	66.41±5.40	76.60±2.65
Power output (watt)			
Control group	249.40±33.12	259.60±24.92	259.60±30.02
NET group	254.28±26.55	289.85±20.88	315.71±13.47
MET group	263.57±45.20	287.57±31.03	313.42±17.52
20-km TT (min)			
Control group	43.87±2.04	44.71±2.83	45.24±1.31
NET group	44.15±3.44	44.69±2.20	40.37±1.51
MET group	43.36±3.93	43.27±2.85	40.99±2.09
Heart rate (bpm)			
Control group	199.8±1.48	197.6±1.51	196.4±1.14
NET group	199.2±1.38	197.7±1.60	199.8±1.34
MET group	198.8±1.57	197.5±1.71	199.7±0.75
RPE			
Control group	15.6±0.89	16.4±0.89	15.2±0.83
NET group	15.2±0.75	16.1±0.37	18.5±0.53
MET group	15.5±0.97	16.8±0.69	18.2±0.75

VO_{2max}: maximal oxygen consumption; NET: normal exponential taper; MET: modified exponential taper; TT: time trial; HR: heart rate; RPE: rate of perceived exertion.

TABLE II.—*Tests of interaction effects of primary variables between experimental groups across the measurement sessions.*

Variables	Type III sum of squares	df	Mean square	F	P value
VO_{2max}					
NET group	710.20	2	355.10	43.92	0.00
MET group	215.71	4	53.92	6.67	0.01
Error	258.67	32			
Power output					
NET group	15304.74	2	7652.37	37.17	0.00
MET group	4140.62	4	1035.15	5.02	0.03
Error	6587.20	32	205.85		
Heart rate					
NET group	26.75	1.25	21.27	16.41	0.00
MET group	35.43	2.51	14.08	10.87	0.00
Error	26.07	20.12	1.29		
RPE					
NET group	33.29	2	16.64	27.85	0.00
MET group	31.19	4	7.79	13.04	0.00
Error	19.12	32	0.59		
20-km TT					
NET group	42.21	1.31	32.09	7.78	0.00
MET group	50.29	2.63	19.12	4.64	0.01
Error	86.70	21.04	4.12		

VO_{2max}: maximal oxygen consumption; NET: normal exponential taper; MET: modified exponential taper; RPE: rate of perceived exertion; TT: time trial.

tion (F=13.04, df=4, $P<0.05$) and 20-km time trial (F=4.64, df=2.63, $P<0.05$). Pair wise comparisons were then performed and detailed results are presented in Table III. The findings indicated that maximal oxygen consumption (VO_{2max}), peak power output, heart rate, rating perceived exertion and 20-km time trial performance values were better for both taper groups compared to the control at post-taper while no differences were observed between the taper groups and the control group at baseline and pre-taper sessions.

TABLE III.—*Pairwise comparison between experimental groups across measurement sessions.*

Variables	Time	Groups	Mean difference	P value	95% CI		Cohen's effects size
					Lower bound	Upper bound	
VO_{2max} (mL/kg/min)	Baseline	Control *vs.* NET	0.25	>0.05	-8.44	8.95	0.03
		Control *vs.* MET	-0.32	>0.05	-9.02	8.36	-0.03
		NET *vs.* MET	-0.58	>0.05	-8.52	7.35	-0.10
	Pre-taper	Control *vs.* NET	-2.25	>0.05	-9.42	4.92	-0.34
		Control *vs.* MET	-3.19	>0.05	-10.36	3.97	-0.42
		NET *vs.* MET	-0.94	>0.05	-7.49	5.60	-0.22
	Post-taper	Control *vs.* NET	-9.77	<0.01	-15.12	-4.41	-1.77
		Control *vs.* MET	-11.10	<0.00	-16.45	-5.74	-2.00
		NET *vs.* MET	-1.32	>0.05	-6.21	3.56	-0.51
Power output (watt)	Baseline	Control *vs.* NET	-4.88	>0.05	-49.72	39.95	-0.16
		Control *vs.* MET	-14.17	>0.05	-59.01	30.66	-0.35
		NET *vs.* MET	-9.28	>0.05	-50.21	31.64	-0.25
	Pre-taper	Control *vs.* NET	-30.25	>0.05	-62.62	2.11	-1.31
		Control *vs.* MET	-27.97	>0.05	-60.34	4.39	-0.99
		NET *vs.* MET	2.28	>0.05	-27.26	31.83	0.08
	Post-taper	Control *vs.* NET	-56.11	<0.00	-81.21	-31.01	-2.41
		Control *vs.* MET	-53.82	<0.00	-78.92	-28.73	-2.18
		NET *vs.* MET	2.28	>0.05	-20.62	25.19	0.14
Heart rate (bpm)	Baseline	Control *vs.* NET	0.51	>0.05	-1.32	2.35	0.36
		Control *vs.* MET	0.94	>0.05	-0.89	2.78	0.62
		NET *vs.* MET	0.42	>0.05	-1.24	2.10	0.29
	Pre-taper	Control *vs.* NET	-0.11	>0.05	-2.13	1.90	-0.07
		Control *vs.* MET	0.02	>0.05	-1.99	2.04	0.02
		NET *vs.* MET	0.14	>0.05	-1.70	1.98	0.08
	Post-taper	Control *vs.* NET	-3.45	<0.00	-4.82	-2.08	-2.77
		Control *vs.* MET	-3.31	<0.00	-4.64	-1.94	-3.43
		NET *vs.* MET	0.14	>0.05	-1.10	1.39	0.12
RPE	Baseline	Control *vs.* NET	0.31	>0.05	-0.77	1.40	0.48
		Control *vs.* MET	0.29	>0.05	-1.06	1.11	0.10
		NET *vs.* MET	-0.28	>0.05	-1.28	0.71	-0.34
	Pre-Taper	Control *vs.* NET	0.25	>0.05	-0.55	1.07	0.44
		Control *vs.* MET	0.54	>0.05	-0.27	1.35	-0.50
		NET *vs.* MET	0.28	>0.05	-0.45	1.03	-1.26
	Post-Taper	Control *vs.* NET	-3.37	<0.00	-4.24	-2.49	-4.73
		Control *vs.* MET	-3.08	<0.00	-3.96	-2.21	-3.79
		NET *vs.* MET	0.28	>0.05	-0.51	1.08	0.46
20-km TT	Baseline	Control *vs.* NET	-0.28	>0.05	-4.45	3.88	-0.49
		Control *vs.* MET	0.51	>0.05	-3.65	4.68	0.81
		NET *vs.* MET	0.79	>0.05	-3.01	4.60	0.10
	Pre-taper	Control *vs.* NET	0.02	>0.05	-3.23	3.27	0.39
		Control *vs.* MET	-1.43	>0.05	-1.81	4.69	0.24
		NET *vs.* MET	-1.41	>0.05	-1.55	4.39	0.26
	Post-taper	Control *vs.* NET	4.86	<0.00	-4.24	6.99	0.86
		Control *vs.* MET	4.24	<0.01	-3.96	6.37	0.77
		NET *vs.* MET	-0.62	>0.05	-0.51	1.31	-0.16

VO_{2max}: maximal oxygen consumption; NET: normal exponential taper; MET: modified exponential taper; RPE: rate of perceived exertion; TT: time trial.

Discussion

The present study investigated the effects of 2-week nodified exponential taper on perceived exertion, time rial performance, VO_{2max} and power output among reglarly trained junior cyclists. It was expected that the nodified exponential taper would provide a superior utcomes when compared to the normal taper and no taer conditions. The results however provide only partial upport for our expectation. Specifically, we observed qually superior outcomes of the two taper protocols when compared to the non-taper group.

Although the difference was not significant, we observed a significant improvement in VO_{2max} and power output among cyclists in both of the taper groups. The normal exponential taper group exhibited greater percent improvement after 2 week taper in with 18.9% and 24.1% for modified and normal exponential taper groups, respectively.

At post-taper period, RPE showed a significant increase during the all-out time trial performance effort after tapering for both intervention groups. Mujika [8] has suggested that the reduced training load associated with the taper may facilitate athletes' recovery. In turn, this may lead to perceived energy increased and ability to work at maximum effort during the time trial, thus the increase in perceived exertion. This speculation is not unfounded and coincides with the participants' heart rate in the present study.

Contrary to our expectation, increase in the power output and VO_{2max} observed in both taper groups did not translate into better time trial performance, although the descriptive data suggest a positive pattern of increased for the taper groups. It has been speculated that changes in physiological adaptation may not necessarily translate into performance outcome as observed among developmental athletes. In their computer simulation study, Thomas *et al.* [13] also did not observed any significant performance improvement following the taper. Thomas *et al.* [13] reasoned that it could be because the participants were elite athletes and this group of athletes usually exhibits a slim margin of performance improvement.

According to supercompensation theory, a recovery would lead to a physiological compensation and homeostasis changes, thus the performance. However, the time in which performance is measured may play an influential role. Specifically, in the present study, performance was measured immediately after tapering and different performance outcome may be obtained if the performance is tracked over time, consistent with different timing of physiological compensation. This notion remains speculated and further performance tracking studies resulting from tapering may provide a clearer picture of the current finding.

Conclusions

Athletes, coaches, and sport scientists are increasingly pushing the limits of human adaptations and training load with the aim of achieving optimal performance at major competitions involving their respective sports. Optimal performance in competition may result from systematic training where fitness is maximized and fatigue levels are minimized.[1, 18] The present finding implied that taper may contribute to this fitness-fatigue interaction. It suggests that both tapering techniques, normal and modified exponential taper are equally effective to positively contribute to physiological adaptations. Integrating taper into the training may give the athletes additional edge to optimal sport performance.

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Oral 38

The Effects of 2-weeks Exponential Taper On Selected Physiological and Biochemical Parameters Among Junior Cyclists

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Introduction: The aim of this study was to investigate the effects of 2-weeks using exponential taper on selected physiological and biochemical parameters among junior cyclists.

Methodology: Twenty seven male junior cyclists (Age= 16.9±0.8 years, Height= 165.6±6.1 cm, Weight=54.2±8.1 kg, BMI= 19.8±2.5) were assigned into 3 groups either by the control group (n=9), exponential taper (n=9), or modified exponential taper (n=9). Both experimental groups followed a 12-week progressive endurance training program followed by a 2-week tapering phase. A simulated 20km time trials performance and a graded exercise test on cycle ergometer was performed before and after tapering. Blood samples were taken before and after tapering and analyzed for blood lactate and serum creatine kinase (CK).

Results & Discussion: The results showed significant increase ($p < .04$) in VO_{2max} for both experimental groups. Also there was a significant increment ($p < .03$) in Power Output (watt) in both experimental groups. A significant ($p < .00$) interaction between experimental groups across experimental time was found for hemoglobin. Haematocrit also significantly ($p < .00$) increased in normal exponential taper and modified exponential taper. Blood lactate was also found to increase significantly ($p < .02$) after tapering in both experimental groups. There was a significant ($p < .05$) decrease in serum creatine kinase in both experimental groups.

Conclusion: It is concluded that physiological adaptations and biochemical changes in junior cyclists are exhibited from the type of taper that were performed. Both exponential taper and modified exponential taper can induce physiological adaptation with reduce volume of training and maintain in intensity of training during tapering phase.

Keywords: cycling; exponential taper; blood lactate; creatine kinase

TECHNICAL REPORT

RESEARCH UNIVERSITY INDIVIDUAL GRANT (RUI)

GRANT NUMBER: *1001 / PPSP / 812134*

OPTIMIZING PHYSIOLOGICAL, PSYCHOLOGICAL AND PERFORMANCE OUTCOMES USING TAPERING TECHNIQUES AMONG JUNIOR CYCLISTS

Research Members:

Associate Profesor Dr. Hairul Anuar Bin Hashim

Dr. Mohd Nidzam Bin Mat Jawis

Associate Profesor Dr. Oleksandr Krasilshchikov

1) INTRODUCTION

Improved competitive performance can be achieved through a well-plan programme following appropriate training principles. A training load combining the elements of intensity, volume, duration and frequency (Smith, 2003; Mujika, Padilla, Pyne, & Busso, 2004) are crucial to elicit training-induced adaptations (Bompa & Haff, 2009). Practically, increasing and decreasing training loads (i.e., intensity and volume) are fundamental training elements to develop the athlete abilities and physiological capacity. This can be implemented following progressive overload principles through sequential plan in the macro-cycle and micro-cycle training plan (Plisk & Stone, 2003). According to Bompa (1999), the concept of periodized training involves alternating periods of sequential increase and decrease of training loads, interspersed with recovery to avoid excessive fatigue. The training loads increased gradually in a progressive manner with recovery or regenerative techniques used throughout the training program (Pyne, 1996).

A growing number of researches have suggested that training regime should be intense enough to evoke physiological capacity at maximum level. The most important part to be considered during competitive phase is to eliminate physical stress (fatigue). This may be achieved by using strategies of increasing or maintaining high intensity training followed by reduced training volumes (Bompa & Haff, 2009; Mujika, 2009; Haff, 2014). This specific strategy is called taper. Taper is recognized as one of the recovery strategies which can be implemented immediately prior to competition to enhance performance (Mujika & Padilla, 2003; Pyne, Mujika & Reilly, 2009). Mujika and Padilla (2003) define taper as a progressive nonlinear reduction of the training load during the period of training in an attempt to reduce the physiological and psychological stress of daily training. It has been well documented that training adaptation occurs during recovery phases after dissipation of fatigue (Smith, 2003).

Tapering techniques has been found as an effective recovery technique from intense training and it has been accepted as an integral part of optimal preparation for competition (Gibala, MacDougall, & Sale, 1994). In sport science literature, taper has been found to elicit a number of benefits among others are improving or retaining athletes physiological status (Neary, Bhambani, & McKenzie, 2003a; Mujika et al, 2004), enhance psychological states (Morgan, Brown, O'Conner, & Ellickson, 1987; Berger et al, 1999), regulate metabolic (Neary, Martin, Reid, & Quinney, 1992) and biochemical parameters (Mujika, Chatard, Padilla, Guezennec, &

Geyssant, 1996; Coutts, Reaburn, & Piva, 2007a), enhance physical strength and power (Martin et al, 1994; Trappe, Costill, & Thomas 2000), and fostering sports performances.

Given its potential benefits, taper has been used in many sports such as swimming (Bonifazi, Sardella, & Luppo, 2000; Trappe et al, 2000; Trinity, Pahnke, Reese, & Coyle, 2006; Papoti, Martins, Cunha, Zagatto, & Gobatto, 2007), running (Shepley, MacDougall, Cipriano, Sutton, Tronopolsky, & Coates, 1992; Houmard & Johns, 1994; Child, Wilkinson, & Fallowfield, 2000; Mujika, Goya, Ruiz, Grijalba, Santisteban, & Padilla, 2002), triathlon (Bannister, Carter, & Zakardas, 1999; Margaritis, Palazzeti, Rousseau, Richard, & Favier, 2003; Vollaard, Cooper, & Shearman, 2006; Coutts, Wallace, & Slattery, 2007b), kayak (Garcia-Pallares, Sanchez-Medina, Perez, Izquierdo-Gabarren, & Izquierdo, 2010), rowing (Steinacker, Lormes, Kellmann, Liu, Reibnacker, Baller, Gunther, Petersen, Kallus, Lehmann, & Altenburg, 2000; Smith, 2000; Meastu, Jurimae, & Jurimae, 2003) and also cycling (Martin & Anderson, 2000; Rietjens, Keizer, Kuipers, & Saris, 2001; Dressendorfer, Petersen, Lovshin, Hannon, Lee, & Bell, 2002; Neary et al, 2003a).

A central focus of taper is reducing physiological and psychological stress and removing residual fatigue with the aim to optimize performance (Mujika, 1998; Smith, 2003). The basic principle of taper is a manipulation of magnitude of reduction of the training volume, intensity, frequency and duration (Hickson & Rosenkoetter, 1981; Shepley et al, 1992; Mujika, 1998; Bannister et al, 1999; Mujika & Padilla, 2003; Bosquet et al, 2007; Wilson & Wilson, 2008; Neary et al, 2012). Mujika and Padilla (2003) propose that the magnitude of taper effects are largely dependent on its specific types, the interaction between taper and pre-taper physical conditions and the types of sports involved (Pyne et al, 2009). It is well accepted that training intensity is one of the key element to maintain training induced adaptations (Hickson, Foster, Pollock, Galassi, & Rich, 1985; Bosquet, Leger, & Legros, 2002; Mujika & Padilla, 2003). Intensity during taper is closely related to the ability to maintain training induced performance adaptations.

It was observed that when higher intensity at 90% of HR_{max} is included in the tapering program, it tends to increase performance. Conversely, if training intensity is reduced, some of the training induced adaptation may be lost and leads to sub-optimal competition performance (Mujika, 2009). Intensity at or below than 70% of HR_{max} during taper period tend to decrease of endurance performance. Successful taper also depends on other variables of training load, especially training volume. The relationship between training intensity and volume is important in order to provide the best strategy in taper (Mujika, 2010). Reduction of the training volume has been gaining attention from many taper related studies (e.g., Mujika, 1998; Smith, 2003). Several ranges of training volume reduction during taper have been documented in many sports. For instance, reduction of training volume between range 50% to 90% have been reported in several studies on swimming, running, cycling and triathlon. It has been recommend that the optimal rate of training reduction is 40% - 70% of training volume, but this is dependent on the method of reduction (Thomas, Mujika, & Busso, 2008).

The challenging part in designing a taper program is to determine the optimal duration of taper. This is because the relationship between intensity and volume of training has been shown to be influenced by the duration of time to recovery (Kubukeli, Noakes, & Dennis, 2002). In taper literature, the duration of taper has been proposed to range from four days (Neary et al, 1992) to four weeks (McConnell et al, 1993). Kenitzer, (1998) study involving a group of female swimmers indicated that a taper of approximately two weeks represented the limit of recovery and compensation time before detraining occurs. Indeed, it has been suggested that athletes who underwent an intense prior to taper require approximately two weeks for full recovery, in which taper may provide the benefit of avoiding loss of fitness level.

Reducing training frequency is another method to reduce the training loads during taper. The reduction of the training frequency between two to four days has been reported in taper literature (Mujika, 2009). Bosquet et al. (2007) indicated that training frequency alone do not have any effect on performance but, it interacts with other training variables, particularly training volume and intensity in order to induce changes in post-taper performance. Another critical element in designing tapering for competitive athlete's is type of taper employed (Thomas et al, 2008). Different types of taper have demonstrated differential outcomes. Taper can be categorized into non-progressive and progressive taper (Bosquet et al, 2007; Mujika, 2009). A Progressive taper refers to a systematic reduction in training load in a gradual fashion, whereas non-progressive taper refers to a standardized reduction with same amount in training load (Mujika & Padilla, 2003).

In progressive taper, training load can be reduced in either linear or an exponential fashion. A Linear taper involves decreasing volume in a stepwise fashion (e.g., 5% reduction from initial values in every workout) (Wilson & Wilson, 2008). On the other hand, exponential taper involves a decrease in training volume at a rate proportionate to its current value in a nonlinear fashion (Wilson & Wilson, 2008). Conversely, in non-progressive taper, training load reduction follows a constant decrease in training volume until the end of taper and this design is labelled as step taper (e.g., 50% reduction in every workout until the end taper) (Whyte, 2006). One of the sub-types of progressive taper, the exponential taper, refers to reduction method in curve wave undulating pattern. By undulating, the reduction of training is either involves slow decay or fast decay (Mujika, 2009). The slow exponential taper involves the slow rate of decay whereas the fast exponential taper involves a faster decay of training volume.

Zakardas, Carter and Banister. (1995) conducted a study to investigate the optimal type of taper in eleven-ironman triathletes. The volume of training was reduced in step and exponential pattern in 10 days. The results showed a significant improvement in 5 km criterion run time and a 5% increase in maximal ramp power output for exponential taper group. However, no significant different was found in step taper group on the same parameters. In a study by Banister et al. (1999) comparing between step and exponential taper, it was shown that the exponential taper group exhibited greater improvement in cycle ergometer and 5 km run performance compared to the step taper. Pyne et al. (2009) suggested that reduced training load followed by a subsequent increased training load in led up to the competition has the potential to contribute to performance gain. However, the number of days in which training load to be increased, remain speculative.

Thomas, Mujika and Busso (2009) conducted a computer simulation study to assess performance benefits by imposing an increased in training load during the final three days of taper period. Data from 13 swimmers were used to run the computer simulation modelling. Their finding showed that the tapering strategy with method of increasing training load during the final three days of taper significantly ($p<.01$) improved compared to traditional taper method (linear). They concluded a short increment in training load provide additional positive training adaptations. Thus, according to Bosquet et al. (2007) and Mujika (2010), tapering involving a planned increase of training load during the final three days prior to competition may be particularly beneficial for athletes to improve performance. However, this suggestion has been based solely on theoretical predictions. Thus, there is a crucial need to confirm or reject this speculation on the basis of an experimental study. To date, no data exist regarding to effects of two weeks of modified exponential taper on physiological, psychological and performance. Therefore, the primary aim of this study is to investigate the effects increase in training load during final three days of taper using modified exponential taper on physiological, psychological and performance outcomes among junior cyclists.

2. OBJECTIVE OF THE STUDY

The objective of the study was divided into general and specific with following aims:

(a) **General objective**

The general objective of this study is to investigate the effects of increase in training load during final three days of taper using modified exponential taper on physiological, psychological and performance outcomes among junior cyclists.

(b) **Specific objective**

The specific objectives of this study are:

(1) To investigate the effects of modified exponential taper with increase load during the final three days of taper on physiological outcomes (VO_{2max}, W_{max}, Maximal heart rate, and RPE) and blood profile (hemoglobin, hematocrit, blood lactate, creatine kinase, lactate dehydrogenase, cortisol and ferritin).

(2) To investigate the effects of modified exponential taper with increase load during the final three days of taper on psychological outcomes (tension, anger, depression, confusion, fatigue and vigor).

(3) To investigate the effects of modified exponential taper with increase load during the final three days of taper on performance outcomes (20 km time trial).

2.1 Research Hypotheses

To achieve the study objectives the following hypotheses are formulated:

Hypothesis 1:

Null Hypothesis (H_{1O}): No significant differences are expected in the physiological outcomes using modified exponential taper with increase load during the final three days taper across the experimental groups.

Alternative Hypothesis (H_{1A}): Significant changes are expected in the physiological outcomes using modified exponential taper with increase load during the final three days taper across the experimental groups.

Hypothesis 2:

Null Hypothesis (H_{2O}): No significant differences are expected in the psychological outcomes using modified exponential taper with increase load during the final three days taper across the experimental groups.

Alternative Hypothesis (H_{2A}): There are significant effects of psychological outcomes using modified exponential taper with increase load during the final three days taper across the experimental groups.

Hypothesis 3:

Null Hypothesis (H_{3O}): No differences are expected in the performance outcomes using modified exponential taper with increase load during the final three days taper across the experimental groups.

Alternative Hypothesis (H_{3A}): Significant changes are expected in the performance outcomes using modified exponential taper with increase load during the final three days taper across the experimental groups.

2.2 Significance of the study

This study provides at least three significant contributions to taper research and practical application. First, it provides guidelines on using exponential tapering techniques to optimize athletes physiological, psychological and cycling performance. Second, it provides evidence on the effectiveness of modified exponential taper with increase load during the final three days among junior cyclists. Third, it provide a data that can be used to choose tapering strategies for youth cycling program to an optimize performance.

3. METHODOLOGY OF STUDY

3.1 Study Design

This study used a pre and post experimental design with both control and an experimental group. The design was chosen to determine if physiological, psychological and performance outcomes were optimized after two weeks of exponential tapering among junior cyclists following a three month training programme. This study was carried out in two phases: the first phase of the study involves a validation of the methodology and a pilot study. The second phases of the study pertain to the main part of study. The flow chart of the study procedures is presented in figure 3.1. Detailed procedures are explained below.

3.2 Brunel Mood Scale (BRUMS) (Terry et al, 1999, 2003)

In this study, the instrument used was the Bahasa Malaysia version of BRUMS (Terry et al, 1999, 2003) (Appendix A). BRUMS is a measure of mood states consisting of six dimensions; depression, confusion, anger, fatigue, tension and vigour. It consists of 24 items measuring these six dimensions. Each item is attached to a 5 point Likert scale ranging from 0 (not at all) to 4 (very much). A sample items for each dimensions are (depression), (confusion), (anger), (fatigue), (tension), and (vigour). This questionnaire have been validated studies in using school level athletes by Hashim, Zulkifli and Yusof, (2010) and SUKMA level athletes by Lan, Lane, Roy and Hanim, (2012). On the basis of these two studies, BRUMS is shown to be a valid and reliable measure of mood states among athletes in the range of 13 – 21 years old.

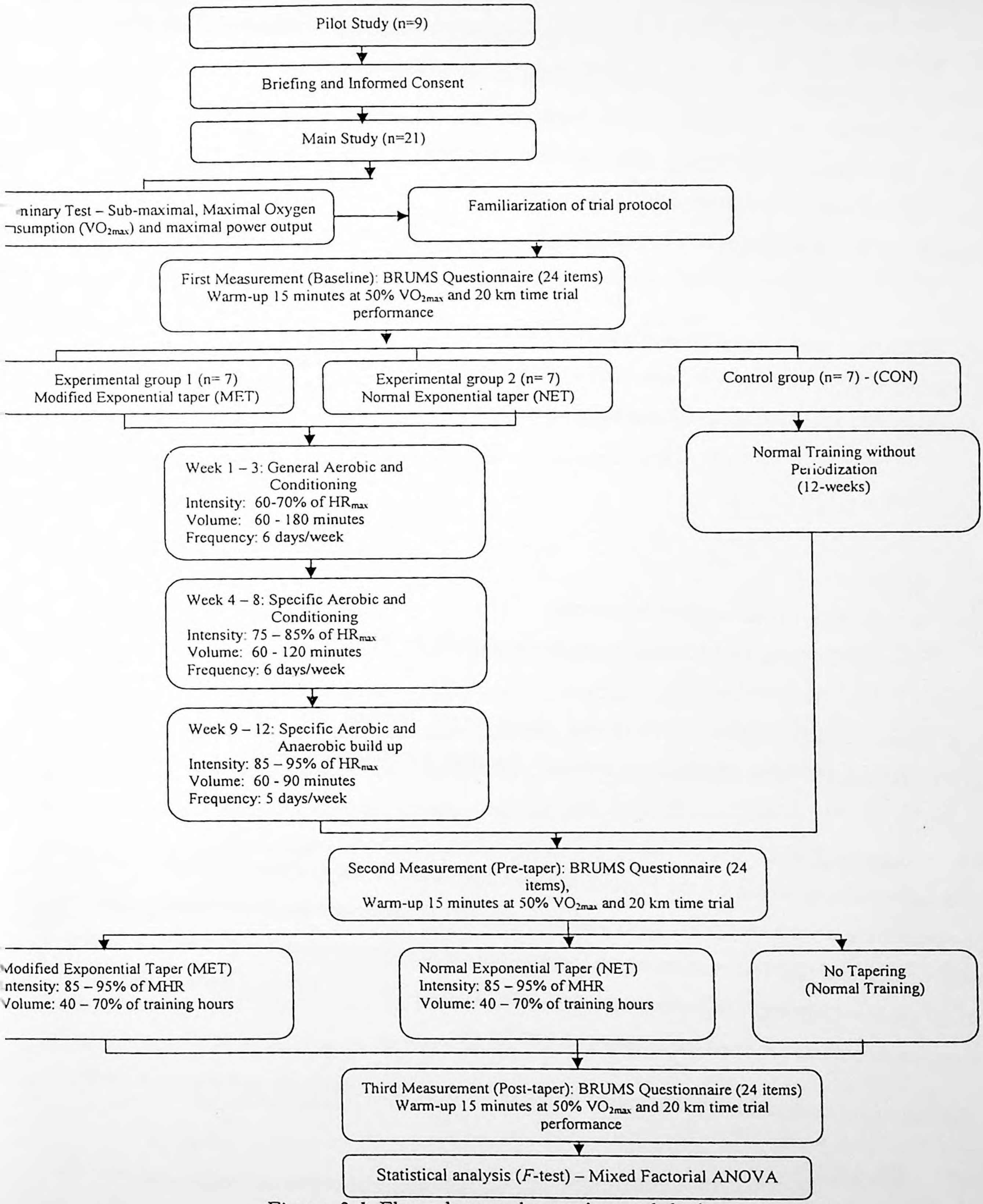

Figure 3.1. Flow chart and experimental design

3.3 Face Validation of the Study Methodology

Prior to the start of the pilot study, a methodology validation study was conducted. This aims to establish the face validity of the protocol of this study, five sport science researchers were asked to determine the suitability of the methodology for this study by using methods suggested by Wilson (1989). They were asked to respond to 12 questions, related to the detailed procedures of methodology. The questions contained two-point response of agreement and disagreement. (See Appendix in B)

3.3.1 Statistical Analysis of Methodology Validation

The content validity ratio (CVR) was used to determine the validity of the methodology used in this study. (Coaley, 2010). CVR was calculated using the following format:

$$CVR = \frac{n - N/2}{N/2}$$

Where,

N = TOTAL (Total number of experts)

n = ESSENTIAL (Numbers of experts who agreed on the given questions)

CVR value ranged from +1 to -1. Value closer to +1 indicate that the experts were in agreement with the items, and that the item was essential for content validity.

3.4 Consent Form

This study was approved by the Human Ethics Committee of the Universiti Sains Malaysia (Appendix C). Prior to the pilot study and main study, all subjects were provided explanation with written and oral information about the experimental procedures and potential risk of the study prior to signing the written consent form (Appendix D). All participants and their guardian or parents returned the signed consent forms.

The following section describes detailed protocol for both the pilot study and the main study.

3.5 Pilot Study

A pilot or feasibility study was designed to gather information in order to improve the experimental procedure and evaluate an efficacy of intervention program in prior to larger study. In this study the pilot study was conducted to enable both the participants and the researcher to get familiarize with the study protocol, identifying problems that arise and also as a mean to validated the study protocols (twelve week of training and two weeks of tapering).

(a) Subjects

Nine male cyclists were recruited from local cycling clubs for the pilot study. The age of the subjects was between 16 to 18 years old. Before taking part, all subjects were given the explanation about the experimental procedures and potential risk participation. Written consent forms were obtained from them and their guardian or parents.

(b) Experimental procedures

As mentioned previously, the experimental procedures for the pilot study was identical to the main study. Details of the experimental procedures are explained in the following main study sections. (See sections 3.6)

3.6 Subjects for the Main Study

(a) Sample Size Determination

The sample size was calculated using G*Power software, version 3.1.10 (Faul et al., 2009). Type I error was set at 0.05. The power of the study was set at 0.85 and estimated effect size (f) of 0.35, indicating a moderate size (Cohen, 1988). The number of groups and measurements was set at three. From calculation done, the total sample size was 21 subjects (n=21). These 21 subjects were randomly matched into three experimental groups with 7 subjects per group. (See section 3.8 for experimental group matching procedure)

(b) Subjects

21 male junior cyclists were recruited from two state cycling teams in Malaysia (Kelantan and Perlis). The aged of the subjects were between 16 to 18 years old. The inclusion and exclusion of the subjects for this study is on the basis of the following criteria;

(i) The inclusion criteria were:

- Subjects were cyclists in medically fit condition and train about five times per week. (Determined from the personal information form, Appendix E).
- They must be between 16 and 18 years of age.

- They had competed in excess of four times in state and national level competition during one calendar year.
- The subjects exhibited a predetermined level of maximum oxygen consumption (VO_{2max}) of at least > 50 ml. $kg^{-1}.min^{-1}$.
- They are not taking any medications during the entire period of the study.

(ii) The exclusion criteria were:

- Voluntary withdrawal from the study
- Subjects who did not adhere to the training program with missing 25% of attendance. Total training program sessions for 12 weeks were 68 sessions and missing of 25% is 17 sessions.

19 subjects from the initial 21 subjects recruited completed in this study. One subject did not complete the training phase being non-adherent to the training program (poor attendance, missing > 25%). Whereas, other one of the subject could not complete the tapering phase due to injury.

3.7 Study Procedures

This study was divided into two phases. In the first phase, preliminary measurements including sub-maximal test, maximal oxygen consumption (VO_{2max}) and maximum power output (W_{max}) for each subject and familiarization of experimental trial were conducted. The second phase consisted of the main experimental trial. Sub-experimental procedure would explained below:

(a) Preliminary Measurement– sub-maximal test

A week prior to the baseline measure, each subject performed the sub-maximal graded exercise test (GXT). The objective was to determine the pre-loaded setting of the power output (watt) and oxygen uptake (VO_{2max}) at certain intensity values before incremental test protocol (Bentley et al, 2007). One day before measurement, subjects were requested to avoid any strenuous activity for 24 hours prior to testing and refrain from any heavy meal, caffeinate or nicotine within two to three hours of testing.

Anthropometric measurement of the subjects such as body weight, percent of body fat and height were measured before they performed the tests. The subjects' body weight and percent of body fat were measured to the nearest 0.1 kg and one tenth of % accordingly by using an electronic body composition analyzer (Tanita® TBF – 410 Japan). A telescopic measuring rod (Seca 220, Germany) was used to measure the height of the subjects to the nearest 0.5 cm. Once the anthropometric variables were measured, subjects were allowed to warm-up by cycling on an electromagnetically brake cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands) for three minutes with no resistance (0 watt). The cycle ergometer was equipped with a racing saddle and handle bars along with the subjects own clip in pedals. Prior to each measurement, oxygen and carbon dioxide analysers were calibrated using two nitrogen-based calibration gases (16.0% O_2, 4.0% CO_2). The output from the gas analysers was calculated by using Vmax software (SensorMedics 2900, USA) to determine the volume of oxygen consumption (VO_2) and carbon dioxide (VCO_2).

The test began with subjects fitted with heart rate sensor (S170 Polar electro, Finland) at the middle of the chest, a mouthpiece and nose-clip. A head gear to support a two-way non-re-breathing valve (Hans Rudolph 2700 series, USA) was attached to the mouthpiece. The subjects were then asked to cycle on the electromagnetically brake cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands) with cadence set at 60 revolution per minutes (RPM) for four minutes at four different stage workload (50, 80, 110, and 140 watt) over a period of 16 minutes. The initial workload was set at 50 watt. Subsequently, the workload was increased by 30 watt at the end of each four minutes increment. All expired air during the test was passed through the mixing chamber, where sensors to the pre-calibrated paramagnetic oxygen and infrared carbon dioxide analysers (SensorMedics 2900, USA) were used to determine the percentage of oxygen and carbon dioxide, respectively. Expired gas and heart rate were measured throughout the test. The result at the final minute of each four minutes increment stage was recorded (Appendix F). All expired air was measured every 20 seconds by gas analyser. Each subject received verbal encouragement during the test by the same laboratory personnel. Thereafter, subject was asked to cool down from the test by cycling until the heart rate was down to 110 beat per minute. Once the sub-maximal GXT was performed, subjects proceeded with the maximal incremental test after 24 hours recovery of the previous test.

(b) Maximal Oxygen Consumption (VO_{2max}) test

VO_{2max} test was carried out, following 24 hours of recovery from the sub-maximal test. For this study, a graded incremental cycling protocol was used to determine subject's VO_{2max} (Storer et al, 1990; Bentley et al, 2007). This method of an increased workload during incremental cycling test has been used to induce a peak VO_{2max} and maximal power output (Bentley et al, 2007). For this test, the subjects were required to cycle to volitional exhaustion during continuous incremental cycle on the electromagnetically brake cycle ergometer (Lode Excalibur Sport, Groningen, The Netherlands). The value of VO_{2max} from sub-maximal GXT that was used as a prediction to maximum oxygen intake and workload (watt) was used as an initial workload for maximal incremental test. Prior to testing, subjects were asked to avoid any strenuous activity for 24 hours before testing and refrain from any heavy meal, caffeinate or nicotine within two to three hours of testing. The calibration of the gas analyzer was done before subject performed the test and identical to sub-maximal procedure. (Please refer to subsection 3.6. (a)). Thereafter, subjects were asked to perform a self-paced warm up at 15 watts for five minutes. Immediately, subjects were fitted with a headgear, mouthpiece, nose-clip and heart rate sensor (S170 Polar electro, Finland) identical to the sub-maximal test. (Subsection 3.6. (a)). Initial workload was set at 50 watt and increased by 16 watt every one minute until exhaustion with cadence was set at 60 rpm. Subjects were verbally encouraged to cycle until volitional exhaustion. Exhaustion was determined when cycling cadence dropped below 60 rpm for more than five second and/or with the onset of volitional fatigue. All expired air and heart rate responses were measured at the end of each one minute stage and were recorded (Appendix F). The VO_{2max} of the subjects were deemed to have been achieved when there is plateau in oxygen uptake (VO_2) despite increasing workloads (American College of Sport Medicine, 2000). Other criteria used to indicate the attainment of VO_{2max} were: (a) failure of heart rate to increase with increases in exercise intensity, and (b) a respiratory exchange ratio of >1.15 (McArdle et al, 2001). After completion of the VO_{2max} test subjects were asked to perform cool down until heart rate decreased to 110 beats per minute.

(c) Maximal Power Output (W_{max}) (obtained from the VO_{2max} test)

W_{max} obtained during an incremental test has been used as a marker of endurance performance in cycling (Hawley & Noakes, 1992; Balmer et al, 2000). W_{max} is defined as the highest wattage athletes can achieved for one completed minute of a given stage (Earnest et al, 2005). In this study, administering an increase in workload during a graded incremental test was used as a method to determine W_{max} (Bentley et al, 2001). W_{max} has been shown to have a high correlation (r = 0.97) with VO_{2max} and the procedure to determine the W_{max} is identical to the VO_{2max} procedure (section 3.6(b)). If an incremental stage was not fully completed prior to protocols termination, the following equation was used to determine the W_{max} (Kuipers et al, 1985):

$$W_{max} = W_{com} + (t/60 \times 16)$$

Where, W_{com} is the power output for the last stage workload completed, t - the time in seconds the final uncompleted workload was sustained. While, 60 is the target time of second in each stage and 16 is the workload increment in watt.

(d) Familiarisation Time Trial Protocol

After the completion of the VO_{2max} test, subjects were asked to familiarise themselves with the experimental protocol prior to the start of the main study procedures. The purpose of this session was to familiarise subjects with what to expect during the actual experimental trial. According to Currell and Jeukendrup, (2008), familiarization is an important aspect to consider when testing experimental or performance protocols in order to reduce intra-subject variation. It has been suggested that subjects should be familiarized with the experimental or performance protocols by completing at least one trial before commencing measurement (Laursen, Shing & Jenkins, 2002). Prior to the familiarisations sessions, subjects completed the BRUMS (Terry et al, 1999, 2003). Subsequently, body weight and percent of body fat were measured prior to the test by using an electronic body composition analyzer (Tanita® TBF – 410 Japan). All subjects were allowed to rest for approximately twenty minutes before the test beginning. All procedures for the familiarization test were identical to the sub-maximal test.

Prior to start the familiarization time trial, subjects were asked to make adjustments to saddle height, pedal and aero-bar handle. For their comfort, the bicycle tires of air pressure were checked before and after the trial to ensure that optimum pressure was maintained. A calibrated Cyclops wireless computer (Cateye corp, Japan) was used to record the speed, revolutions per minute and distance. All the testing sessions were conducted at the same room temperature and humidity (25°C, 70% relative humidity).

The familiarisation time trial began with subjects warming up by cycling at 50% VO_{2max} on an ergo cycle for 15 minutes. The cadence was set at 70 rpm. All expired gases and heart rate were measured throughout the familiarisation test at the end of each minute. Immediately, on completion of the warming up, subjects were transferred from the ergo cycle to the bicycle used to perform time trial protocols. They were required to cycle for the 20 km time trial using bicycle aluminium road bike (Trek corp, USA) as fast as possible. Throughout the time trial, subjects used the same bicycle with mounted on a jet-fluid trainer-cycling roller (Cycleops, USA). Subjects were instructed to maintain time trial technique by using aero-bar. Subjects were also informed to choose free fitting gear according to their comfort and not to change the cycling pace. During the 20 km time trial, the subjects were not given any feedback with regard to time before and after the taper (Neary et al, 1999). Respiratory gas exchange responses were monitored for two min at every five km interval during the time trial. Heart rate was recorded continuously throughout the time trial using a Polar heart rate monitor (Polar electro, Finland) and Rating of Perceived Exertion (RPE) was taken using the Borg scale (Borg, 1982). These variables were measured at 5 km, 10 km, 15 km and at the end of 20 km interval. The time taken to complete the time trial was recorded using digital timer (Seiko, Japan). After the completion of measurement, subjects were allowed to cool down by continuing cycle until the heart rate reaches110 beat per minute. Afterward, each subject was given a food diary intake and was asked to complete the record for at least three days before the first measurement (baseline) (Appendix G). They were then instructed to follow the same diet before the second and third measurement to minimize differences in the resting muscle glycogen concentrations.

3.8 First Measurement (Baseline)

The actual baseline measurement began one week after the subject's completed the familiarisation trial. It was performed in an improvised laboratory room equipped with halogen lamps (Philips -500W, France) and air conditioner (York®, Malaysia) to control the room temperature. The temperature inside the room was maintained at thermo neutral (25°C) using air conditioner and halogen lamps were able to increase the ambient temperature in the room. If needed, a water-bath (Memmert W350t, Germany) was used to maintain the relative humidity (RH) of 70% in the room. The RH and temperature in the room were measured by using Digital Psychrometer (Extech Instrument RH300, USA). A standing fan was used to direct air to the subject to mimic airflow in an open air environment and fan speed was set at level 1 (2.4 $m.s^{-1}$).

Preceding the baseline measurement, subjects were asked to refrain from any strenuous training within 24 hour. Subjects were also asked to fast over night for 10-hour before arriving at the laboratory. However, they were allowed to drink plain water during the fast. When subjects arrived at the laboratory for time trial, they were immediately asked to complete the BRUMS to determine their mood states. The standard response timeframe was use is "How you feel right now?". Prior to the time trial, blood samples was taken with an in-dwelling butterfly cannula protocol (Vasocan® - 22G: 1", B. Braun Malaysia). The subjects forearm skin was prepared with an alcohol swab in the supine position. Then, an in-dwelling butterfly cannula was inserted into a forearm vein and an extension tube was connected to it to facilitate repeated blood withdrawals (e.g. baseline, before warming up and after 20 km time trial). Approximately 6 ml blood sample was collected by using a 10 ml syringe (Becton Dickinson, Singapore). Following each drawn, approximately 0.8 ml of heparinised saline (10 IU heparin sodium in 1 ml 0.9% NaCI, Braun, Malaysia) was injected into the extension tube for blood sampling to maintain the patency of blood. The first 1 ml of blood sample was drawn using a 5 ml sterile syringe (Becton Dickinson, Singapore) and it was excluded from blood analysis because it contains heparin saline in the blood. Blood samples were collected during the baseline, before the warm up and the after the 20 km time trial.

Thereafter, the subjects were given a standardized breakfast which included a piece of bread (Gardenia®, Malaysia) and 500 ml plain water. Then, subject's nude body weight was recorded before warm up and after completion of the time trial by using an electrical body composition analyzer (Tanita® TBF – 410 Japan). Subjects were allowed to rest for approximately twenty minutes before commencing the time trial. For the 20 km time trial, subjects were seated on the ergometer for approximately five minute to stabilize the values of respiratory exchange ratio (RER) to below than 0.7. Room temperature, RH % and resting heart rate were recorded before the start and throughout of the trial at five minute interval respectively (Appendix H). The time trial protocol performed was identical to the time trial in familiarisation session (As described in section 3.6 (d)).

Immediately after warm up, subjects ingested 3 $ml.kg^{-1}$ body weight of plain water at the start of trial and at every 5 kilometre interval during the trials and after completing the trial. All physiological parameter such as VO_2, RPE, heart rate, room temperature, RH % and 20 km time trial parameter such as time (ms^{-1}), cadence (rpm), and speed (km/h) were recorded by using the time trial performance form (Appendix I). After the completion of the time trial, the nose-clip, mouthpiece, head gear and as well as heart rate sensor was removed from the subject. Post exercise nude body weight was obtained after the subjects had towel-dried themselves. All the subjects repeated the same procedures for the subsequent trials.

3.9 Experimental Group Matching Procedure

After completion of the baseline measure, subjects were assigned to the control and two experimental groups by using matching procedure. The baseline values of VO_{2max} was used as a matching criteria to ensure that the subjects did not differ significantly between the groups. The three study groups were modified exponential taper (MET), normal exponential taper (NET) and control group (CON). Each group consisted of seven male cyclists (n=7). The values of the VO_{2max} for each of the groups are presented in Table 3.1.

Table 3.1

The values of VO_{2max} for matching groups

Components for matching groups	**Modified Exponential Taper (MET)**	**Normal Exponential Taper (NET)**	**Control (CON)**
VO_{2max}	65.02	64.44	64.70

Note: There is no significant difference between the subjects of the modified exponential taper, normal exponential taper and control groups in their values on the VO_{2max} in the baseline measurements.

3.10 Training Programme

After the subjects were matched into three different groups, two experimental groups underwent 12 weeks an intervention training programme, while the control group followed their own training programme as set by their coach. Experimental and ntrol groups were trained separately to avoid contamination. The intensity, volume, and frequency of training were standardized to ensure that all groups receive equal training loads during the intervention programme. To ensure the control group had an equal training loads relative to the experimental groups, the intensity of training was set at 60% to 95% of HR_{max} and the total training sessions was set at 68 sessions. All groups were trained under the supervision of the qualified coaches (at least a level 2 Sports Science Coaching certificate and level 1 Sport Specific Certificate in Cycling issued by the National Sport Council) and were closely monitored for a period of 12 weeks. The interval endurance training protocol for cycling was used in this study. Interval training refers of repeated bouts of mix intensity (high, moderate, low) exercise, interspersed with recovery periods (Hawley et al, 1997; Buchheit & Laursen, 2013). This protocol operates with high volume low intensity, moderate volume moderate intensity, and high intensity low volume (Jeukendrup, 2002; Laursen, 2010; Laursen et al, 2002). The percentage of maximum heart rate (HR_{max}) was used to express intensity of training in the endurance training protocol. In this study, high-intensity refers to the highest or maximum of effort with ranges between 85 – 95% of HR_{max}. While, moderate-intensity involves moderate to vigorous effort ranging between at 75 – 85% of HR_{max} and lastly, low intensity refers to sub-maximal of effort ranging between 60 – 70% of HR_{max} (Seiler, 2010). Each protocol was divided into three distinct phases. The detailed training protocol is illustrated in the Table 3.2.

Table 3.2: 12 weeks periodized interval training protocol for cycling.

Training Variables	**First Phase (Week 1 - 3)**	**Second Phase (Week 4 - 8)**	**Third Phase (Week 9 - 12)**
Interval training protocol	High volume, low intensity	Moderate intensity, moderate volume	High intensity, low volume
Intensity	60 – 70% of HR_{max}	75 – 85% of HR_{max}	85 – 95% of HR_{max}
Duration	60 - 180 minutes	60 – 120 minutes	60 – 90 minutes
Frequency	6 days.wk^{-1}	6 days.wk^{-1}	5 days.wk^{-1}

Throughout the duration of the training session, the subject's heart rate was closely monitored by using the heart rate monitor (Polar electro, Finland). Each subject was given a training log to record duration of training, distance covered, maximal and average heart rate. Subjects were asked to complete the training log after each training session and checked by the coach. (Appendix J).

3.11 Second Measurement (Pre-taper)

After the completion of the 12 weeks periodized training program, subjects underwent the second measurement (pre-taper). The measurement procedure was identical to the one administered previously (see subsection 3.7).

3.12 Tapering Protocols

After the completion of the second measurement (pre-taper), both experimental groups underwent one of two tapering protocols that are either modified exponential or normal exponential taper programs for duration of two weeks. The intensity of training during tapering phase was standardized for both groups at 85-95% of HR_{max}. The intensity of training for both the experimental groups during the tapering phase was set at 85-95% of HR_{max}, (Mujika, 1998, 2009). The training volume was reduced to 40-70% of training hours for the two weeks, while, frequency of training remained without change. The interval training method was used in the tapering intervention training. The magnitude of the reduced training volume was determined from the maximum training duration during the three weeks preceding the taper (Mujika, 2009; Mujika & Padilla, 2003) thus, equalling 90 minutes for the training program. The training loads were quantified using the rating of perceived exertion (RPE) method as suggested by Foster et al. (2001). The control group meanwhile continued their training with the same program as before until the end of the two weeks. The normal exponential taper protocol includes a progressive reduction of training duration to 40-70% of the pre-taper value. Exponential taper is defined as a fast rate of reduced volume training in an exponential fashion (Mujika, 2009). In this protocol, reduction of training volume was obtained in training hour (minute) without increasing training load during the final three days of the taper phase. The manipulation of training volume for normal exponential taper is described in Table 3.3.

Table 3.3:
Normal Exponential Taper Protocols

Tapering days	1	2	3	4	5	6	7	8	9	10	11	12	13	14
% of volume reduction	40	50	rest	65	50	60	rest	50	45	rest	55	60	70	rest
Training hours in minutes.day^{-1}	54	45	0	32	45	36	0	45	50	0	41	36	27	0

The modified exponential taper protocol involves the reduction of training volumes followed by an increase in training load during the final three days (Thomas, Mujika, & Busso, 2009) from 40-70% of the pre-taper value. The manipulation of training volume for modified exponential taper is described in Table 3.4.

Table 3.4:

Modified Exponential Taper Protocols

Tapering days	1	2	3	4	5	6	7	8	9	10	11	12	13	14
% of volume reduction	40	50	rest	65	50	60	rest	50	70	rest	60	50	40	rest
Training hours in minutes.day^{-1}.	54	45	0	32	45	36	0	45	27	0	36	45	54	0

During the tapering period, subjects were trained under the supervision of qualified coaches and closely monitored by the researcher. Monitoring is a crucial process to ensure that subjects comply with the tapering protocols. Throughout the tapering periods, subjects' heart rate were closely monitored using heart rate monitors (Polar electro, Finland). Each subject was given a training log to the intensity and duration of training, distance covered, speed, cadence, RPE, resting and maximal heart rate. Subjects were asked to complete the taper training log after each taper training session and checked by the coach. (Appendix K).

3.13 <u>Third Measurement (Post-taper)</u>

After the completion of the two weeks tapering period, subjects underwent the third measurement (Post-taper). The measurement procedure was identical to the one administered previously (subsection 3.7).

3.14 <u>Measuring Physiological Outcomes</u>

Procedures for obtaining VO_{2max}, W_{max}, HR, and RPE were explained in details in sections 3.6 and 3.7 previously. The blood parameters and biochemical analyses were carried out as described below:

3.14.1 Blood Parameters and Analysis

Blood parameters such as hemoglobin (Hg), hematocrit (Hct), lactate (Lac), creatine kinase (CK), lactate dehydrogenase (LDH), cortisol and ferritin were measured. Approximately, six ml of blood was withdrawn from the subjects during baseline, 0' minute and at the end of 20 km time trial during each trial. Two ml of the blood collected was placed in the Ethylenediamine tetra-acetic acid (EDTA-2K, INSEPACK®, Malaysia) tube for the measurement of hemoglobin and hematocrit level. No centrifugation was used, for the analysis of blood for these two parameters.

One ml of the blood was transferred into the Sodium Fluoride and Na-Heparin (INSEPACK®, Malaysia) anticoagulant tube for analysis of plasma lactate. The blood samples were separated by centrifugation (10 minutes, 4000 rpm, 4°C: Hettich-Rotina 46RS, Germany). After centrifugation, the plasma was divided equally into two tubes using pipette technique and stored at -20°C (Acson, Malaysia) for the subsequent analysis of lactate. The plasma of lactate concentration was measured using a chemistry analyzer (Architect c4000, USA).The remaining three ml of blood were transferred into plain tubes for serum. Separation serum from the blood sample was separated by centrifugation (10 minutes, 4000 rpm, 4°C: Hettich-Rotina 46RS, Germany). The serum from this sample was divided into two equally portions and placed in tubes and stored at -20°C for the subsequent analysis of CK, LDH, cortisol and ferritin.

3.14.1.1 Hemoglobin Analysis

(a) Principle of the test

Hemoglobin is an iron-containing compound found in the red blood cells, which transports oxygen around the body. When it is mixed with a solution containing potassium ferricyanide and potassium cyanide oxidize iron from methemoglobin, the potassium cyanide combines with methemoglobin to form cyanmethemoglobin, which is a stable colour pigment which can be photometrically at a wave length of 540 nm.

$$\text{Hemoglobin} \xrightarrow{\text{Ferricyanide}} \text{Methemoglobin}$$

(b) **Procedure of the test**

0.01 ml blood from a collecting tube which contains EDTA was added to 2.5 ml Drabkin's solution in a test tube and mixed. The tube was then stirred in a dark place for 10 minutes. The absorbance of sample (A_{sample}) and standard ($A_{standard}$) were obtained by using a spectrophotometer (SPEKOL 1200, Analytikjena, Germany) at 540 nm wavelength. Concentration of hemoglobin (g.dL-1) was calculated by using formula as described below:

$$\text{Concentration of hemoglobin } (g.dL^{-1}) = \frac{\text{Sample Absorbance} \times \text{Standard concentration}}{\text{Standard Absorbance}}$$

Where, standard concentration is 14.36 $g.dL^{-1}$.

3.14.1.2 Hematocrit Analysis

(a) **Principle of the test**

Hematocrit is the percentage of red blood cells to the total blood volume. Normal percentage of hematocrit for men is about 45% and 40% for women.

(b) **Procedure of the test**

For hematocrit level measurements, blood samples from the EDTA tube were drawn into the capillary tube at least half full but not exceeding ¾ of the tube length. The end of capillary tube then was closed with plasticine for centrifugation in the micro-hematocrit centrifuge (Hematocrit 20, Hettich zentrifugen, Germany). The centrifugation was set for 10 minutes at 12,000 rpm. The hematocrit level was then measured using a Hawksley Reader (Hawksley, England). The level of hematocrit in % was calculated using the formula as described below:

$$\frac{\text{Red blood cell volume}}{\text{Total blood sample volume}} \times 100$$

3.14.1.3 Lactate Analysis

(a) Principle of the test

Lactate is converted to pyruvate and hydrogen peroxide (H_2O_2) by lactate oxidase. Peroxidase catalyzes the oxidation of the chromogen precursor by H_2O_2 to produce a coloured dye. The increase in absorbance at 548 nm is directly proportional to the lactate concentration in the sample. L-lactate oxidized to pyruvate by the specific enzyme lactate oxidase (LOD).

L-lactate + O_2 ↔ pyruvate + H_2O_2

Peroxidase (POD) is used to generate a coloured dye using the hydrogen peroxide generated in the first reaction.

H_2O_2 + H-donor + 4-aminoantipyrine+ ↔ chromogen$^+$ + 2-H_2O

(b) Procedure of the test

The plasma lactate was directly analyzed using a chemistry analyzer (Architect c4000, USA). The analyzer automatically calculates the plasma lactate concentration for each sample using a conversion factor.5 mg/dl x 0.111 = mmol/L.

3.14.1.4 Creatine Kinase Analysis

(a) Principle of the test

Creatine kinase, catalyze the transfer of a high energy phosphate group from creatine phosphate to Adenosine diphosphate (ADP). The adenosine triphosphate (ATP) produced in this reaction is subsequently used by phosphorylate glucose to produce glucose-6-phospate (G-6-P) in the present hexokinase. G-6-P is then oxidized by nicotinamide adenine dinucleotide phosphate (NADP) to nicotinamide adenine dinucleotide phosphate reduce (NADPH). The rate of formation of NAPDH is monitored at 340 nm and is proportionate to the activity of the creatine kinase. These reactions occur in the presence of N-acetyl-L-cysteine (NAC) which, is present as an enzyme re-activator.

Creatine Phosphate + ADP $\xrightarrow{CK}$ Creatine + ATP