The Effect of Long Term Physical Training on the Development of Mental Toughness in Recreationally Active Participants

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Abstract

This study investigated the effect of a long-term training program on the development of mental toughness (MT). Thirty (2 female and 28 male) recreationally active participants (age: 33.53±6.83years; height: 177.41±7.11cm; weight: 78.40±11.94kg; maximal oxygen uptake (VO_{2max}): 47.00±6.48 ml.kg^{-1}.min^{-1}; mean±SD) undertook 6 months of training prior to completing a long-distance triathlon. Participants completed mental toughness questionnaires (MTQ48) at 0, 2, 4, and 6 months of training and 1-month post-race. Data analysis included repeated measures ANOVAs for each MTQ48 variable with consideration to faster and slower finishers. Faster and slower finishers demonstrated non-significant differences ($p>0.05$) on all MT criteria. Overall mental toughness (OMT) improved from baseline-post race (cohens d = 0.52; $p<0.01$) and month 2 post race (d = 0.39; $p<0.01$), commitment improving from baseline-post race (d = 0.60; $p<0.05$) and confidence increasing from month 2 post race (d = 0.39; $p<0.05$). The findings indicate that long term training culminating with competitive experience favourably impacts MT.

Introduction

Long distance triathlon involves participation in three long distance events: swim, cycle, and run all involving set distances (i.e., a 3.8 kilometer (km) swim, a 180 km cycle, and a 42.2 km run). Due to the high demands placed upon the athlete, particularly regarding the long duration of the three events, psychological skills may facilitate an athlete's ability to cope with the adversities of training and competition. Mental toughness improves the ability to cope (Clough & Strycharczyk, 2012; Schaefer, Vella, & Allen, 2016) and thrive under pressure (Gucciardi, Hanton, Gordon, Mallett, & Temby, 2015). Clough and Strycharczyk (2011) define MT as the quality that determines how people deal with challenge, stressors, and pressure, irrespective of prevailing circumstances. Hardiness theory provided a theoretical framework for the development of the 4Cs model of MT (Kobasa, 1979). Clough, Earle, and Sewell (2002) adapted hardiness theory with the addition of confidence, creating the 4C's of MT (confidence, commitment, control, and challenge).

MT counteracts the negative effects of a coach's controlling interpersonal styles (Gucciardi, Stamatis, & Ntoumanis, 2017). Consequently, mentally tough individuals can identify controlling coach behaviour and experience negative emotions associated with non-supportive coaching styles (Crust, 2009; Nicholls, Morley, & Perry, 2016); however, they remain focussed and maintain control of their behaviour. This highlights that MT facilitates coping and thriving under pressure (Gucciardi et al., 2015) but does not explain direct associations with performance. Although evidence exists of MT predicting basketball performance (Newland, Newton, Finch, Harbke, & Podlog, 2013), difficulties exist in predicting performance in open-skilled and reactive environments. Therefore, further research should clarify the effect of MT on performance, particularly in novice competitors aiming to improve performance or individuals undertaking general physical activity.

In a military context, Smith, Wolfe-Clark, and Bryan (2016) demonstrated that self-confidence reduced suicide risk in United States Air Force security personnel. Additionally, Newell and Rayner (2014) demonstrated that MT scores predicted final course grades in British Army recruits. MT and performance decreased when recruits received non-contingent punishment, indicating the need for leader support as well as exposure to a challenging environment (Crust & Clough, 2011). Thus, MT facilitates coping with pressure during the training and development of British Army recruits.

In a higher education context, MT predicted students passing the first year of a UK undergraduate degree (Crust, Earle, Perry, Earle, Clough, & Clough, 2014). In adolescents aged 11-16, MT improves educational attainment, attendance, and behaviour (St Clair-Thompson, Bugler, Robinson, Clough, McGeown & Perry, 2015). Additionally, MT predicted higher achieving first year undergraduate students (Hunt, Pollak, Stock, Usher, Lynam, & Cachia, 2014). Mentally tough female participants achieved higher module assessment scores. MT, therefore, improves educational attainment due to improving the ability to perform under pressure. The effect of MT on performance requires further research in the sport context due to the limited amount of empirical supporting evidence.

MT changes in response to psychological interventions (Bell, Hardy, & Beattie, 2013; Gucciardi, Gordon, & Dimmock, 2009a; Gucciardi, Gordon, & Dimmock, 2009b) and significant life events (Marchant, Polman Clough, Jackson & Levy, 2009). Bull, Shambrook, James, and Brooks (2005) proposed a model to guide sport psychologists who design interventions to improve athlete MT. These authors propose that MT improves during long term exposure to a challenging yet supportive environment.

Connaughton, Wadey, Hanton, and Jones (2008) identified that MT develops long-term and involves the motivational climate, key individuals from the athlete's sport, family and peers, intrinsic motivation to succeed, and sport specific and life experiences. This underlines that MT development requires a conductive environment and motivational climate, including appropriate levels of challenge and support.

Gucciardi, Gordon, and Dimmock (2009a) demonstrated that psychological skills training (PST) improved MT in 3 youth-aged (under 15 years old) Australian football teams over a 6-week time-period. Both MT specific PST and generic PST programmes resulted in similar improvements in MT subscales with no significant differences between the intervention groups ($p>0.05$). MT did not change in the control group ($p>0.05$) implying that the intervention had an impact upon MT. Therefore, PST results in measurable improvements in MT over a short time-period (6 weeks). Although PST improves MT, researchers need to clarify if MT develops in a challenging environment including manipulation of training demand (e.g., chronic training load increases).

This study aims to investigate how MT changes in recreational participants, during a longitudinal training programme, and to examine how MT affects race time. The authors hypothesise the following: (a) MT scores would increase over the course of the training programme in response to the increasing training load; and (b) faster finishers would have higher MT scores (i.e., Overall MT, Control, Confidence, Commitment, and Challenge) than slower finishers.

Method

Participant recruitment and Pre-Screening

A UK based Higher Education Institute granted ethical approval for this study. Following commercial advertisement, 30 participants volunteered for initial pre-screening (see Table 1 for demographic information). All participants completed a health screen questionnaire and provided consent from their General Practitioner for a longitudinal endurance training program. Participants demonstrated no evidence (including family history) of heart abnormalities, hypertensive conditions, coronary heart disease, or diabetes. Participants, identified as recreationally active, had no prior experience in long-distance triathlons. A standard incremental step protocol assessed cardio-respiratory fitness to confirm that they met the criteria for recreationally active. The authors define recreationally active as individuals training less than 4 times per week with a maximal oxygen uptake (VO_{2max}) of 30-50 $ml.kg^{-1}.min^{-1}$ for females and 35-55 $ml.kg^{-1}.min^{-1}$ for males, based on the broad ranges of individuals previously observed in the laboratory. The research team measured maximal oxygen uptake using a Computrainer ergometer system (RaceMate Inc., Seattle, USA) and standard road bike (Giant TCR, Giant, Radlett, Hertfordshire) in the Human Performance Laboratory.

Table 1. Baseline demographic data (mean ± standard deviation)

	Faster finishers (n=15)	**Slower finishers (n=15)**	**Total (n=30)**
Age (years)	33.60 (6.12)	33.47 (7.69)	33.53 (6.83)
Height (cm)	179.02 (4.75)	175.80 (8.74)	177.41 (7.11)
Weight (kg)	80.11 (10.22)	76.69 (13.59)	78.40 (11.94)
Body fat percentage (%)	17.57 (5.96)	20.43 (5.55)	19.00 (5.84)
VO_{2max} (ml.kg.$^{-1}$min^{-1})	49.47 (6.14)	44.53 (6.02)	47.00 (6.48)
Race time (mins)	700.27 (30.19)	865.20 (39.96)	782.73 (90.81)

Instrumentation

The MTQ48 measures MT on a 5-point Likert scale ranging from anchors *strongly agree* to *strongly disagree*. The questionnaire assesses MT and its subcomponents: confidence, commitment, control, and challenge (Clough et al., 2002). The MTQ48 has established factorial validity (Perry, Clough, Crust, Earle, & Nicholls, 2013), criterion-related validity (Clough et al., 2002) and construct validity (Horsburgh, Schermer, Veselka, & Vernon, 2009). Additionally, Horsburgh et al. (2009) demonstrated acceptable reliability, indicated by coefficient alphas ranging from 0.74 (challenge and control) to 0.92 (overall MT). The researchers used an Excel spreadsheet to collate all official race times from the race director of the event.

Procedure

Participants took part in an observational research study involving a 6-month training program in preparation for a long-distance triathlon. This event comprised a 3.8 km swim, 180 km cycle and 42.2 km run under International race regulations. An accredited sport and exercise physiologist prescribed a periodised training program focusing on swimming, cycling, and running as well as functional training (see Figure 1).

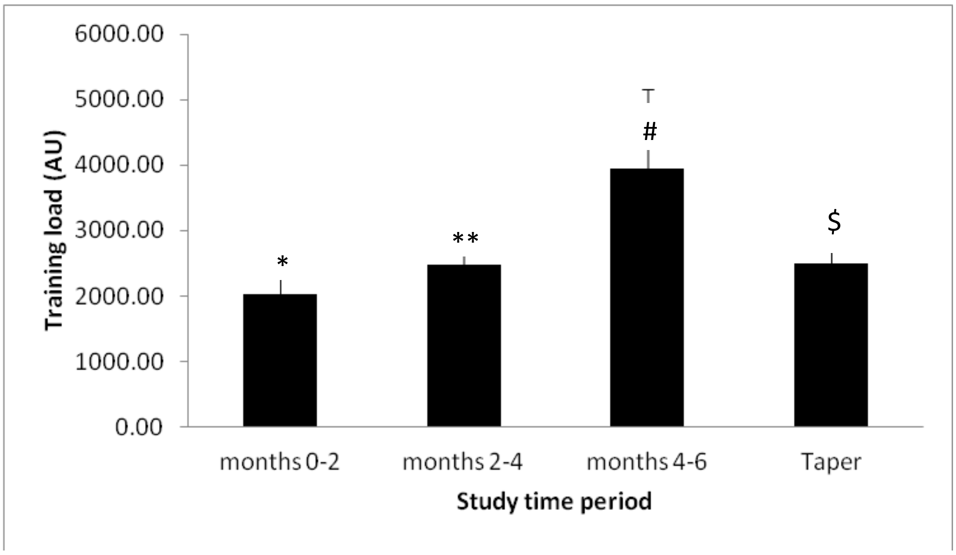

Figure 1. Participants' mean training load. Error bars represent cohort standard deviation. *indicates significant difference from months 2-4 ($p<0.05$) and 4-6 ($p<0.01$) and taper ($p<0.05$). **indicates significant difference from months 0-2 (0.01) and 4-6 ($p<0.01$). # indicates significant difference from months 0-2, 2-4 and taper ($p<0.01$). $ indicates significant difference from 0-2 months ($p<0.05$) and months 4-6 ($p<0.05$).

Participants completed a minimum of 80% of total training volume per week (see Table 2) assessed using a modified training load method (Foster et al., 2001). Participants detailed training type, modified rating of perceived exertion (RPEmod) and session duration (minutes) and weekly training load (arbitrary units) calculated as session duration multiplied by RPEmod (Foster et al., 2001).

Table 2. Planned and actual training load (mean ± standard deviation).

	Planned training load (AU)	**Actual training load (AU)**	**Percentage of planned training load completed (%)**
Months 0-2	1789.38	2027.60 (522.32)	113.31
Months 2-4	2568.75	2475.73 (620.76)	96.38
Months 4-6	3277.50	3947.13 (1210.73)	120.43
Taper	2789.17	2492.92 (739.82)	89.38

Participants completed the MTQ48 online using a hyperlink embedded within emails sent to the whole cohort via an online application. Each participant completed the MTQ48 at 0, 2, 4, and 6 months of training and 1-month post-race. Participants completed the questionnaire within 48 hours. The researchers excluded outstanding or late submissions from the final analysis to standardize the procedure.

Data Analysis

The researchers assigned participants into one of two groups based on finishing time: (a) 15 of the fastest finishers and (b) 15 of the slowest finishers (for demographic information see Table 1). A mixed measures repeated ANOVA (using SPSS, Chicago, IL v.23) for Overall MT (OMT) assessed each of the MTQ48 sub-scales: challenge, commitment, control, and confidence. Each analysis included finish time (i.e., fastest and slowest) as the between-factor, and the temporal point of MTQ48 administration (i.e., 0,2,4,6 and 1-month post-race) as within-factor. Bonferroni-adjusted pairwise comparisons assessed specific time differences. Additionally, confidence intervals (CI) and effect size coefficients (partial eta squared, Cohen's *d*) estimated effect magnitudes. Pearson's correlation coefficients and partial correlations controlling for VO_{2max} compared race times and MTQ48 variables. Pearson's correlations also assessed the relationship between changes in MT and changes in training load. An alpha level of ≤0.05 ascertained statistical significance on all analyses.

Results

OMT scores revealed a significant main effect for time, $F_{(4, 112)} = 6.29$, $p < 0.01$, $\eta_p^2 = 0.18$ (see Figure 2). In general, OMT scores increased as time progressed, including one-month post-competition. Pairwise comparisons revealed significantly higher OMT post scores (mean±SD: 6.70±1.73) compared to baseline scores (5.80±1.71, 95% CI [0.31, 1.50], $d = 0.52$, $p < 0.001$) and T2 scores (5.97±2.03, 95% CI [0.13, 1.33] $d = 0.39$, $p < 0.01$). Furthermore, OMT demonstrated no significant effects for group and group by time interaction.

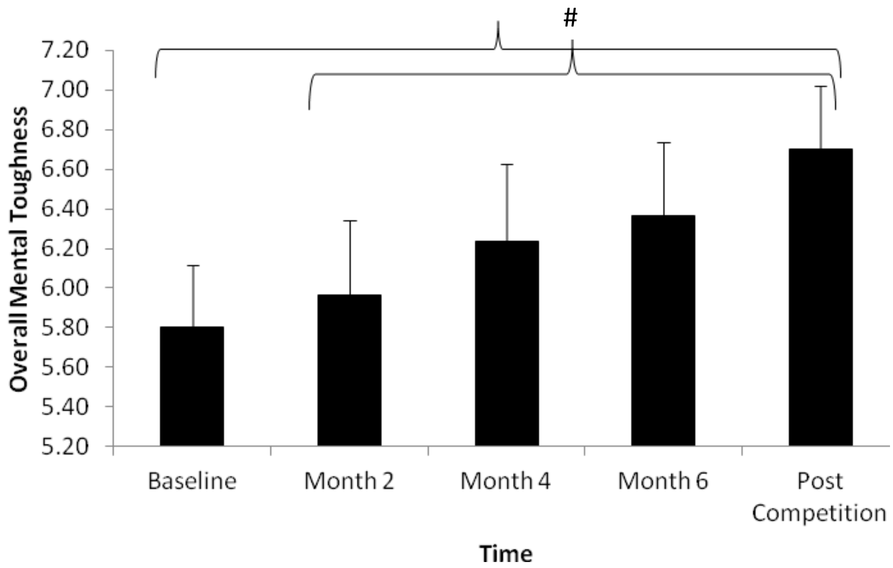

Figure 2. Assessment of mean overall mental toughness (OMT) across the training program (# denotes significant difference from month 2 to post race 1 month: p<0.01; * denotes significant difference from baseline to post race 1 month: p<0.01). Data presented as mean±SD.

The challenge sub-scale demonstrated significant main and interaction effects, for time, $F_{(4, 112)} = 2.23$, $p = 0.07$, $\eta_p^2 = 0.07$, group, $F_{(1, 28)} = 0.72$, $p = 0.41$, $\eta_p^2 = 0.03$ and the time by group interaction, $F_{(4, 112)} = 0.58$, $p = 0.68$, $\eta_p^2 = 0.02$. Thus, challenge sub-scale scores did not differ over time or between the fastest and slowest finishers. Furthermore, challenge demonstrated no significant effects for group and group by time interactions.

Commitment demonstrated a significant main effect for time, $F_{(4, 112)} = 6.29$, $p < 0.001$, $\eta_p^2 = 0.18$ (see Figure 3). Commitment scores (6.60±1.47) significantly increased from baseline (5.80±1.19, 95% CI [0.11, 1.49], $d = 0.60$, $p < 0.05$) during follow-up pairwise comparisons.

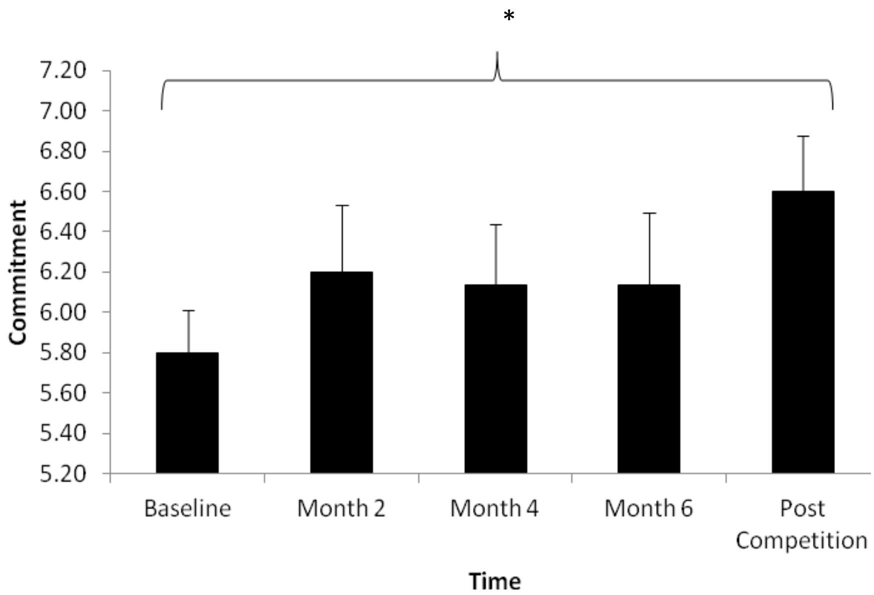

Figure 3. Assessment of mean commitment across the training period (* denotes significant difference from baseline to post race 1 month: p<0.05). Data presented as mean±SD.

Perceived control scores did not change among the MTQ48 administration times, $F_{(4, 112)} = 1.97$, $p = 0.11$, $\eta_p^2 = 0.07$, and between fast and slow finishers, $F_{(1, 28)} < 0.001$, $p = 1.00$, $\eta_p^2 < 0.001$. Additionally, no significant time by group interaction occurred, $F_{(4, 112)} = 0.25$, $p = 0.91$, $\eta_p^2 = 0.01$.

Confidence scores demonstrated a main effect, $F_{(4, 112)} = 4.30$, $p < 0.01$, $\eta_p^2 = 0.13$ (see Figure 4). Scores increased with time with differences becoming significant between post-race scores (6.27±2.08) and month 2 scores (5.53±2.19, 95% CI [0.09, 1.38], $d = 0.39$, $p < 0.05$). Confidence scores of fastest and slowest finishers did not differ, $F_{(1, 28)} = 0.03$, $p = 0.86$, $\eta_p^2 < 0.01$. Additionally, no significant group by time interaction occurred, $F_{(4, 112)} = 1.00$, $p = 0.41$, $\eta_p^2 = 0.03$.

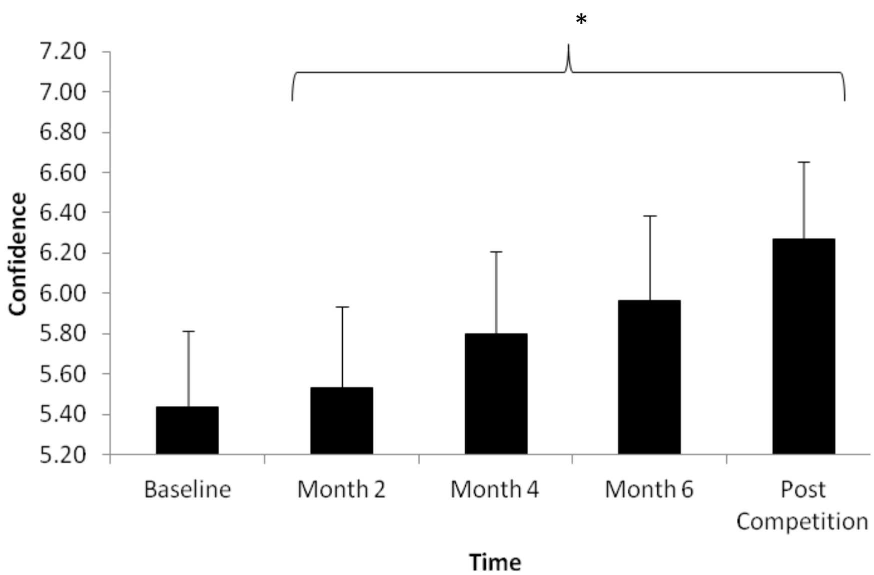

Figure 4. Assessment of mean confidence across the training programme (* denotes significant difference from month 2 to post race 1 month: p<0.05). Data presented as mean±SD.

Race time and VO_{2max} correlated negatively ($r=-0.42$, $p<0.05$). No significant correlations occurred between MTQ48 variables and race time ($p>0.05$). Additionally, race time and MTQ48 variables did not significantly correlate while controlling for VO_{2max} ($p>0.05$). No significant correlations between the changes in MT and the changes in training load occurred ($p>0.05$).

Discussion

This study aimed to investigate how MT changes during a challenging endurance training programme, and to compare MT between faster and slower finishers. The authors hypothesised the following: (a) MT scores would increase over the course of training in response to the increasing training load; and (b) Faster finishers would have higher MT scores (i.e., Overall MT, Control, Confidence, Commitment, and Challenge) than slower finishers.

MT Score Changes Over Time

Overall MT, confidence, and commitment significantly increased one-month post-race, compared to baseline (OMT, commitment) and month 2 (confidence, OMT). MT has modifiable characteristics demonstrated by changes in commitment and confidence over the course of training. These two characteristics increased 1-month post-race, implying that successful completion of the race caused these changes. Previous research demonstrates that MT can increase with PST (Gucciardi et al., 2009a). Additionally, research identifies that MT can improve in a challenging and supportive environment (Bull et al., 2005; Crust & Clough, 2011). Current results support these findings and confirm that MT improves when progressively increasing training load in preparation for an event.

Simons and Keeler (1993) proposed a model of sport commitment identifying 5 factors influencing commitment. These determinants include: sport enjoyment, involvement alternatives, personal investments, social constraints and involvement opportunities. Long-distance triathlon may increase perceived enjoyment and competence which positively affects motivation to persevere with an activity (Timo, Sami, Anthony, & Jarmo, 2016; Jaakkola, Yli-Piipari, Watt, & Liukkonen, 2016). Crust and Clough (2011) recommend reflection upon positive as well as negative experiences to shape and reinforce attributions for success and find solutions to poor performance. Further research should investigate whether reflective practice can reinforce commitment to training.

Commitment fluctuated at months 4 and 6 possibly because of a decrease in perceived enjoyment and satisfaction. This phase of the study corresponded with increases in training load (refer to Figure 4) and fatigue. Earle, Hockey, Earle, and Clough (2015) demonstrated that commitment predicted effort applied to a task and that effort applied caused the development of fatigue. Therefore, individuals with higher commitment to training may fatigue quickly due to applying more effort to training (Earle et al., 2015) and personal investments (financial, time and effort) towards training may facilitate persistence (Simons & Keeler, 1993) until fatigue dissipates.

Confidence may have improved 1-month post-race due to successfully completing the race. Performance accomplishments improve confidence (Desharnais, Bouillon, & Godin, 1986; Feltz, Landers, & Raeder, 1979; Feltz & Mugno, 1983; McAuley, 1985; Weinberg, Yukelson, & Jackson, 1980) when associated with positive affect (Bang & Reio, 2017). Further research should explore individual experiences of long term training for a long distance triathlon race. Researchers should further investigate the impact of challenging competitive experiences on other areas of participants' lives. This should include the effect on educational attainment and business performance.

Relationship between MT and Race Time

MT did not differ between faster and slower finishers at any time during training and post-race. Therefore, MT does not affect race time in recreationally active participants with no previous experience of competing in a triathlon. Confounding factors may include the following: race inexperience causing variation in pacing strategies, physical preparedness and environmental conditions during the long duration of the race (average race time±SD = 782.73±90.81 minutes equivalent to 13 hours and 3 minutes). Significant negative correlations between VO_{2max} and race times ($r = -0.42$, $p<0.05$) indicate that physical fitness influenced race time. Semi-partial correlations indicated that MT did not correlate with race time ($p>0.05$). Thus, physical factors predict race time more accurately than MT in novice triathletes.

Based on the findings from the current paper, MT has a supportive role to performance enhancement and indirectly affects performance. Specifically, MT influences coping mechanisms and the tendency to thrive in stressful situations.

Personal and situation-dependent factors affected race time. Individual participants attended with different strategies and varying degrees of preparedness. A small number of individuals attended the event location 1-week before the race and had time to mentally prepare themselves through self-prescribed visualisation and relaxation strategies. Other participants arrived within a few days of the event and did not have time to acclimatise and mentally prepare. Individual circumstances affected time of arrival proving difficult to standardise, highlighting the complexities involved in mentally preparing for an international event. Future research should standardise travel arrangements necessitating participant attendance at the venue at least 1-week pre-race.

Contrary to predictions, MT did not differ between fast and slow finishers at any time point in the study. The small sample size may have increased the likelihood of type 2 errors. Descriptively, OMT and the sub-category (i.e., 4C's) scores at baseline in the faster finishers increased on all variables, while at post-race slower finishers scored higher (or equal) on all variables except for challenge. Thus, endurance training increased MT, especially for relatively lower performing triathletes. However, diminishing returns may cause slower finishers to demonstrate higher sensitivity to MT development. Therefore, researchers and practitioners should interpret these results with caution. Further research should further investigate these assumptions.

Newell and Rayner (2014) revealed that army recruits with higher MT improved performance more than individuals with lower MT when army trainers gave participants contingent and non-contingent punishment. Recruits perform in hostile environments and require tolerance of non-contingent punishment. MT decreased with the negating stimulus (non-punitive punishment). However, MT mediates the relationship between controlling coach behaviours and learning effectiveness (Gucciardi et al., 2017). Consequently, mentally tough individuals perform to a higher level of relative performance regardless of negative emotions experienced with controlling coach behaviour. Although mentally tough individuals thrive on pressure, non-punitive punishment decreases MT. Consequently, coaches should challenge athletes by progressively increasing the training demand while giving support and encouragement to promote reflection on positive and negative experiences.

Conclusion, Limitations and Future Research

A major limitation of this study includes the self-report nature of the MTQ48 impeding clear distinction of mentally tough individuals (Adams et al., 2005; Motl, McAuley, & DiStefano, 2005). Self presentational bias may decrease the accuracy of questionnaire reports making it unclear how MT scores affect behaviour. Therefore, future research should examine the effect of changes in self-reported MT on behaviour.

In conclusion, MT improved post-race after a 6-month period of endurance training in previously recreationally active participants. Future research should examine the mechanisms (e.g., achievements, social factors) causing changes in MT. Practically, sport coaches should carefully structure a training plan to progressively challenge athletes with regular indications of success. Furthermore, reflecting on success and failure can encourage rational attributions. Although MT does not affect triathlon race times, MT may have a beneficial impact on athlete experiences including the ability to frame challenges as an opportunity.

This study demonstrated evidence of physical factors predicting race time more accurately than MT in novice triathletes. MT may contribute to race time in more experienced athletes with homogenous physiological abilities. MT seems a relevant concept for military training, education and business due to increases in the ability to thrive under pressure.

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Discussion Questions

1. What are the possible mechanisms for changes in MT as a result of challenging stressors?
2. What are possible ways that training workload can affect commitment to training?
3. What are the practical considerations that may impact the relationship between MT and race times in triathletes?
4. Can practitioners build mental toughness training into a physical training programme for athletes?

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