P-12

INVESTIGATING MUSCULAR ADAPTATION TO A SWIM-TYPE AND A TRACK-TYPE TRAINING REGIME IN ELITE JUNIOR ATHLETES

JANEL BAILEY, RACHAEL IRVING, PAULA DAWSON, DIALO-RUDOLPH BROWN

UNIVERSITY OF THE WEST INDIES, MONA

ABSTRACT

BACKGROUND: The short preparatory phase and dense competition period, that characterizes the swim and track macrocycle may induce physiological stress and inefficient muscular adaptation. AIM: To investigate changes in markers of muscular adaptation (muscle thickness, muscle strength, blood lactate) induced by swim-type and track-type training regimes in elite junior athletes. METHOD: The study included 39 runners and 20 swimmers. Frequencies (TF) and volume (TV) of each training type (sprint, resistance, endurance, plyometric) were collected using a training regime questionnaire, along with internal training load (TL) which was determined using the session perceived exertion method. This data was collected during the general preparation (T1), specific preparation (T2), and competition (T3) phase of the 28-week swim and track and field macrocycle. Isometric muscle strength, muscle thickness (MTH), basal (b La-), and post-exercise lactate (POE La-) were measured at T1 and T3. RESULTS: Statistical analyses revealed significant differences in training data at T1 only. Swimmers focused predominantly on endurance training and were exposed to significantly less resistance training relative to runners (U=-4.52, p=0.01). Significant hypertrophic changes (Δ:3.43, p=0.01) were observed among runners only, who also demonstrated greater overall strength improvements after adjusting data for baseline (T1) strength values. Despite both groups exhibiting significant improvements in bLa- (p=0.01) and POE La- (p=0.01) levels, swimmers had more favorable changes, after adjusting for T1 levels. CONCLUSION: Following the literature, swim-type training-induced more favorable metabolic changes, while track-type training was successful in inducing functional (strength) and morphological (muscle thickness) changes. Improvements in strength and lactate levels are indicative of increased resistance to muscle fatigue. Given that training protocols were most distinguishable at T1 with significant variations in endurance and resistance training. It is recommended that coaches carefully consider the balance between endurance and resistance training during this phase, to account for possible limitations in muscle adaptation markers as this may lead to increased vulnerability to fatigue.

INTRODUCTION

Research with young elite athletes has shown that insufficient time in the preparatory phase and limited recovery during competition induces physiological and psychological stress across the season, which can then impact the adaptation to training stimuli (1). The relationship between training stimuli and muscle adaptation follows the dose-response principle which explains the relationship between the physiological stress associated with the frequency, duration, and intensity of the varying training modalities. Failure to effectively adapt to the rigors of a training macrocycle has been hailed as a hallmark of muscle fatigue (2). Hypertrophic response and strength changes within muscle groups have been extensively researched as key aspects of muscle adaptation (3-6). Studies have also provided evidence that peak blood lactate is a possible indicator of performance status among well-trained runners (7) as this may provide insight into the adaptability of muscles to sprint-type training (8, 9). However, the attempt to transfer findings to elite young athletes is futile as youth athletes differ from adults in their metabolic capacity and (i.e., lower anaerobic capacities) and neuromuscular performance (i.e., lower ability to fully activate muscles) as well as the risk of sustaining injuries (e.g., anterior cruciate ligament injuries) (10, 11).To the authors' knowledge, there is a limitation in the literature regarding muscle adaptability using multiple markers of adaptation in response to a full swim and track macrocycle of training. Given the adaptability of skeletal muscle to training, morphologically and physiologically tracking its response to current traditional training regimes, may elucidate areas of weakness and strength within these programmes. Early detection of injury and fatigue may facilitate better interventions in the approach to procuring the health of Jamaican junior athletes, thus facilitating a greater transition to the senior level.

EXPERIMENTAL DESIGN

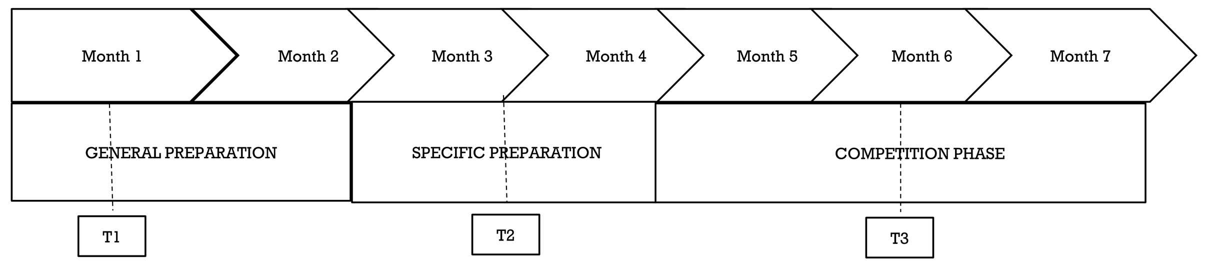

Figure 1: Overview of experimental design. T1 – test session at the beginning of the preparation phase, T2- mid-way the specific preparation period, T3 – test session mid-way the competition phase.

METHOD

Table 1: Demographic characteristics of participants.

	Runners (n=39)	Swimmers (n=20)
Age (years)	15.50± 1.98	13.31± 1.94
Height (cm)	171.54±8.91	168.98±7.04
Weight (kg)	62.78±10.96	58.53±9.14

METHODS

Fifty-nine (59) junior elite athletes participated in this study, this included 20 swim athletes and 39 runners. Frequencies (TF) and volume (TV) of each training type (sprint, resistance, endurance, plyometric) were collected using a training regime questionnaire. Internal training load (TL) was determined using the session perceived exertion method. Training data were collected during the general preparation (T1), specific preparation (T2), and competition phase (T3) of the 28-week swim and track and field macrocycle. Isometric muscle strength, muscle thickness (MTH), basal (b La-), and post-exercise lactate (POE La-) were measured at T1 and T3. Lactate levels were tested before, and after (3,8 and 15 mins) a 400m run and 50m swim for runners and swim athletes, respectively. Data was analyzed using SPSS ersio23 software. Effect sizes were calculated by converting partial eta-squared to Cohen's d.

RESULTS

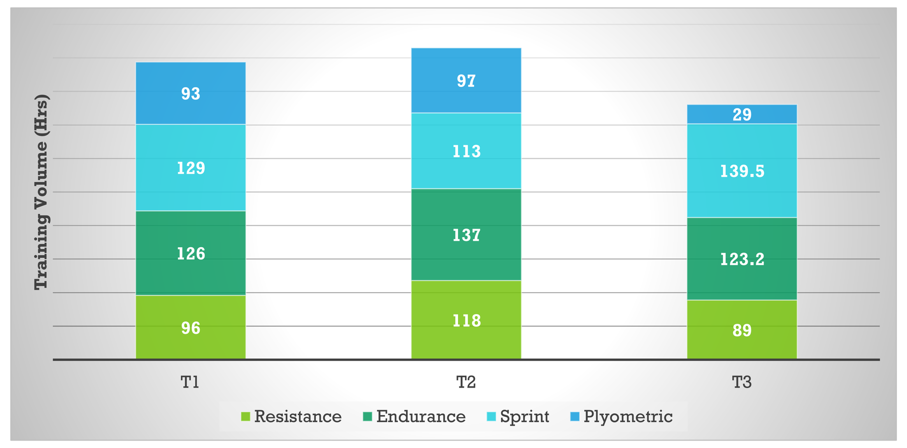

Figure 2: Cumulative training volume of swimmers and runners for each training type, within each training period.

During P1, swimmers were exposed to significantly less resistance (U=-4.52, p=0.01) and plyometric (U=-4.10, p=0.01) training compared to runners. No significant difference in the training volume of any exercise type was observed during P2. During P3 there was a significant group difference for resistance training volume (U=-2.58, p=0.01).

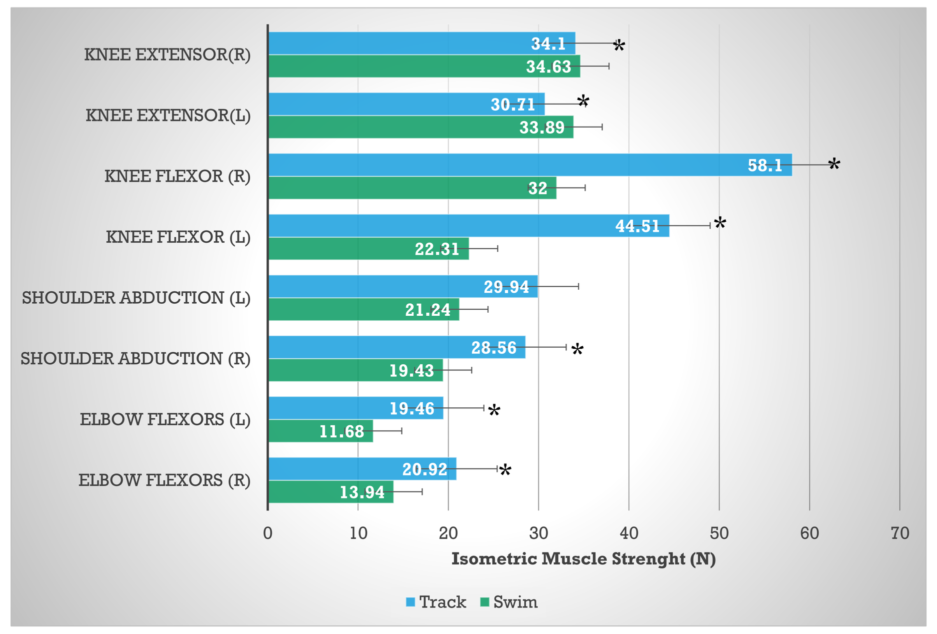

Figure 3: Change in isometric muscle strength in swim and track elite athletes.(*p<0.05)

Small significant between group differences were observed in the upper body for right elbow flexors (ES=0.16, p=0.011), left elbow flexors (ES=0.28, p=0.01), right shoulder abductors(ES=0.23, p=0.01), and a trivial significant between group difference was observed for the left shoulder abductors (ES=0.09, p=0.01). In the lower body, small significant between group differences were observed in the right knee flexors (ES=0.44, p=0.01) and left knee flexors (ES=0.40, p=0.01). While trivial significant between group differences were observed for the left (ES=0.07, p=0.01) and right knee extensors (ES=0.02, p=0.01).

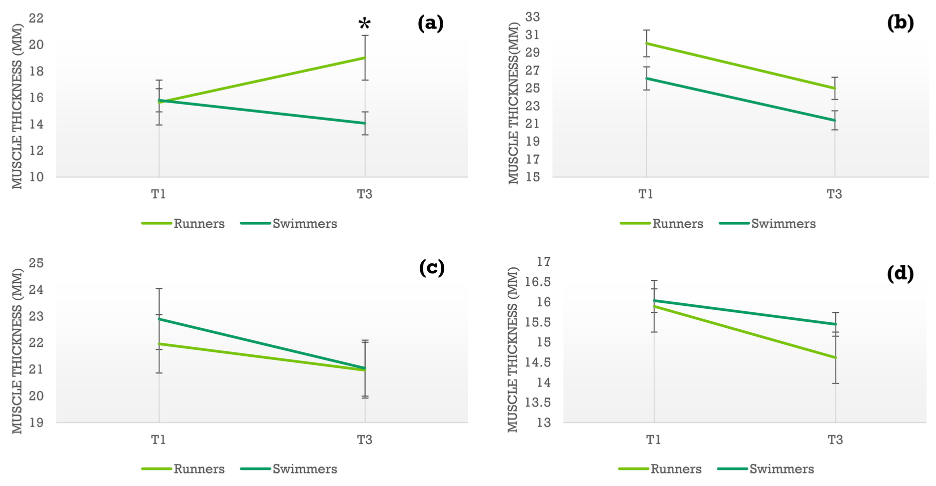

Figure 4: Changes in muscle thickness in swimmers and runners between T1 and T2 (*p<.0.05)

(a)-rectus femoris, (b)-biceps, (c)-waist, (d)-Triceps

Statistical analyses revealed there were limited changes in muscle thickness. However, Significant hypertrophic changes (Δ:3.43, p=0.01) were observed among runners only. Wilcoxon sign rank test revealed track-type training elicited a significant increase in rectus femoris muscles (P1:15.74±3.42mm, P3:19.00±4.06mm, Z=-4.19, p=0.01) only. Swim type training was observed to elicit decreases in bicep muscles (P1: 26.88±6.07mm, P3:21.36±5.42mm, Z=-2.74, p=0.01). Quade's ANCOVA analyses show that there were small significant between group differences at P3 for rectus femoris (p=0.01, ES=0.35) when adjusted for MTH data obtained at P1.

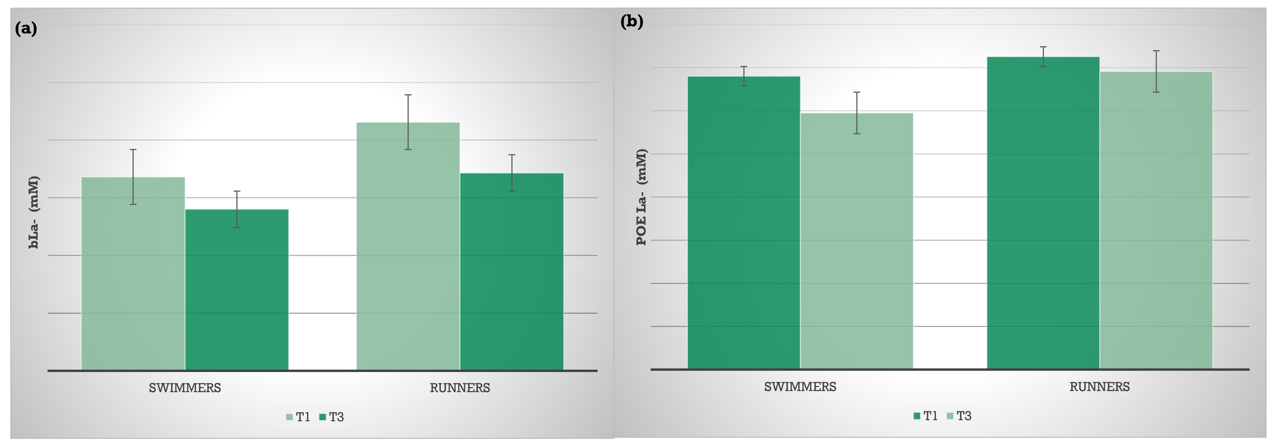

Figure 5. Change in bLa^- (a) and POE La^- (b) levels in junior elite athletes

There was a small significant main effect of time (ES=0.32, p=0.01) on POE La^- only. However, using ANCOVA, with P1 POE La^-levels as covariates, it was observed that changes across the season were not significant. Additionally, no significant group*time interaction (p>0.05) POE La^- or bLa- across the season.

CONCLUSIONS

Improvement in muscle strength and lactate levels are indicative efficient training adaptability (12-14). However, our results indicate that swimmers comparatively showed limited improvement in strength and muscle size across the season, while runners exhibited comparatively higher basal and post exercise lactate levels at T1 and T3. It can then be assumed that both groups exhibited varying maladaptive tendencies across the season. Failure to effectively adapt to the rigors of a training macrocycle has been hailed as a hallmark of muscle fatigue (2). Additionally, the long-term athletic development (LTAD) model suggests that there exists a window of adaptability beyond which adolescent athletes become less sensitive to training-induced adaptation, thereby leading to potential failure in future athletic potential (15). Given the limited preparatory phase which runners and swim athletes are exposed to, the window of adaptability may be further constrained for these individuals. Muscle fatigue is also regulated by training modality exposure. Following the literature our study also indicated that swim type training was more conducive to metabolic adaptation, as its training protocols focused predominantly on maximizing aerobic capacity and muscle endurance (16-18), while track-type training, which incorporates high levels of resistance training, facilitated greater power and strength gains (19). It is therefore recommended that coaches carefully consider the balance between endurance and resistance training, particularly within the general preparation phase, as this may ultimately impact training adaptability across the full macrocycle.

REFERENCES

1. Lesinski M, Prieske O, Helm N, Granacher U. Effects of Soccer Training on Anthropometry, Body Composition, and Physical Fitness during a Soccer Season in Female Elite Young Athletes: A Prospective Cohort Study. Frontiers in Physiology. 2017;8(1093).
2. Kenttä G, Hassmén P. Overtraining and recovery. A conceptual model. Sports medicine (Auckland, NZ). 1998;26:1-16.
3. Bandy WD, Lovelace-Chandler V, McKitrick-Bandy B. Adaptation of skeletal muscle to resistance training. The Journal of orthopaedic and sports physical therapy. 1990;12(6):248-55.
4. Baz-Valle E, Schoenfeld BJ, Torres-Unda J, Santos-Concejero J, Balsalobre-Fernández C. The effects of exercise variation in muscle thickness, maximal strength and motivation in resistance trained men. PLOS ONE. 2019;14(12):e0226989.
5. Saunders PU, Pyne DB, Telford RD, Hawley JA. Factors affecting running economy in trained distance runners. Sports medicine (Auckland, NZ). 2004;34(7):465-85.
6. Sharifnezhad A, Marzilger R, Arampatzis A. Effects of load magnitude, muscle length and velocity during eccentric chronic loading on the longitudinal growth of the vastus lateralis muscle. The Journal of experimental biology. 2014;217(Pt 15):2726-33.
7. Beckford T, Irving R, Golden K, Poudevigne M. Metabolic Markers in Jamaican Male Sprinters. 2017;32:72-9.
8. Bret C, Messonnier L, Nouck J, Freund H, Dufour A-B, Lacour J-R. Differences in Lactate Exchange and Removal Abilities in Athletes Specialised in Different Track Running Events (100 to 1500 m). International journal of sports medicine. 2003;24:108-13.
9. McArdle WD, Katch F, Katch V. Individual differences and measurement of energy capacities. Exercise Physiology. 2010:225-47.
10. Alentorn-Geli E, Myer GD, Silvers HJ, Samitier G, Romero D, Lázaro-Haro C, et al. Prevention of non-contact anterior cruciate ligament injuries in soccer players. Part 1: Mechanisms of injury and underlying risk factors. Knee surgery, sports traumatology, arthroscopy : official journal of the ESSKA. 2009;17(7):705-29.
11. Zauner CW, Maksud MG, Melichna J. Physiological considerations in training young athletes. Sports medicine (Auckland, NZ). 1989;8(1):15-31.
12. Halson SL. Monitoring training load to understand fatigue in athletes. Sports medicine (Auckland, NZ). 2014;44 Suppl 2(Suppl 2):S139-S47.
13. Theofilidis G, Bogdanis GC, Koutedakis Y, Karatzaferi C. Monitoring Exercise-Induced Muscle Fatigue and Adaptations: Making Sense of Popular or Emerging Indices and Biomarkers. Sports (Basel, Switzerland). 2018;6(4).
14. Wan JJ, Qin Z, Wang PY, Sun Y, Liu X. Muscle fatigue: general understanding and treatment. Experimental & molecular medicine. 2017;49(10):e384.
15. Ford P, De Ste Croix M, Lloyd R, Meyers R, Moosavi M, Oliver J, et al. The Long-Term Athlete Development model: Physiological evidence and application. Journal of sports sciences. 2011;29:389-402.
16. González-Boto R, Salguero A, Tuero-del-Prado C, González-Gallego J, Márquez S. Monitoring the effects of training load changes on stress and recovery in swimmers. Journal of physiology and biochemistry. 2008;64:19-26.
17. Hellard P, Avalos-Fernandes M, Lefort G, Pla R, Mujika I, Toussaint J-F, et al. Elite Swimmers' Training Patterns in the 25 Weeks Prior to Their Season's Best Performances: Insights Into Periodization From a 20-Years Cohort. Frontiers in Physiology. 2019;10(363).
18. Pollock S, Gaoua N, Johnston MJ, Cooke K, Girard O, Mileva KN. Training Regimes and Recovery Monitoring Practices of Elite British Swimmers. Journal of sports science & medicine. 2019;18(3):577-85.
19. Fam T. Year-Round Individualized Resistance Training for Collegiate Track & Field Event Groups: Track and Field News; 2018 [Available from: https://trackandfieldnews.com/current-issue/?issue=february-2020.