EXERCISE TRAINING PATTERNS AND ANTHROPOMETRIC CHARACTERISTICS OF AMATUER MOTORCYCLE ROAD RACERS

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Exercise is an important component in preparing for competition. Failure to properly train can lead to performance decrements, fatigue and injury. Scientific based sport conditioning programs are available for a variety of sports. However, there is lack of information concerning sport conditioning for motorcycle road racing. The purpose of this investigation was to conduct an initial study of body mass index (BMI), estimated cardiorespiratory fitness (VO_{2max}) and exercise training patterns of expert and novice amateur motorcycle road racers.

A total of 53 Western Eastern Roadracing Association (WERA) racers provided self-reported height, weight, age, gender, resting heart rate (RHR), physical activity habits, aerobic exercise training patterns and resistance exercise training patterns on an on-line survey. Height and weight was used to calculate BMI. Gender, age, RHR and habitual physical activity were used to estimate VO_{2max}. The Global Physical Activity Questionnaire was employed to assess total physical activity (PA) in minutes per week. A supplemental survey was utilized to assess exercise training participation, frequency, duration, resistance exercise selection, repetitions and sets. An independent sample t-test was used to compare BMI and estimated VO_{2max} between expert and novice racers. A Mann-Whitney u test was performed to compare Total PA. Pearson Chi-Squared tests were used to compare exercise training patterns.

Expert racers had a significantly lower mean BMI ($p < .05$) compared to novice racers, 23.55 and 25.77, respectively. No significant difference was found in estimated VO_{2max} between expert and novices racers, 46.65 ml/kg/min and 44.31 ml/kg/min, respectively. A significant difference ($p < .05$) was found in Total PA. Expert racers had a mean total PA of 1110 min/wk and novice racers had a mean total PA of 743 min/wk. A significant difference ($p < .05$) was established in one resistance exercise (i.e. lunges). Novices had a larger participation rate compared to expert racers in the lunge resistance exercise.

The findings do not provide sufficient information to conclusively develop a sport-specific exercise program. However, this study provides preliminary data concerning anthropometric and fitness characteristics of motorcycle road racers. Additional research is necessary to fully understand characteristics associated with improved motorcycle road racing performance.

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1.0 INTRODUCTION AND RATIONALE

1.1 INTRODUCTION

There is extensive research to demonstrate that regular exercise improves cardiorespiratory fitness, body composition, muscular strength and endurance, and results in numerous biochemical and physiological adaptations within the human body (Powers & Howley, 2004; Baechle & Earle, 2000). These benefits of exercise have been shown to be related to improvements in health-related outcomes (American College of Sports Medicine [ACSM], 2002) as well as serve as the cornerstone of exercise training programs to improve athletic performance (Kraemer, 1985; Kraemer, Fleck & Evans, 1996). This has resulted in sport-specific exercise training programs being developed for sports such as golf (Lephart, Smoliga, Nyers, Sell & Tsai, 2005), football (Murlasits & Langley, 2002), baseball (Szymanski & Frederick, 2001), bull riding (Barrett, Butterwick & Smith, 2007), surfing (Everline, 2007) and others (T. Burger & M. Burger, 2006; Judge, 2007; Jones & Bampouras, 2007; Gamble, 2006; Marques, Gonzalez-Badillo & Kluka, 2006).

Motorcycle road racing is increasing in popularity in the United States, with competition occurring at the regional (amateur), national (professional) and international (elite) levels. The physiological demands of a motorcycle road racer may include counteracting g-forces of acceleration and braking through muscular strength and endurance, fine motors skills of throttle control, shifting gears and clutch manipulation (Gobbi, Francisco, Tuy & Kvitne, 2005), thermoregulation resulting from the requirement to wear leather racing suits for safety and protection in the event of a crash, and fatigue resulting from races lasting approximately 45 minutes. Despite these unique demands on motorcycle road racers, there is limited published research on physiological characteristics of individuals participating in this sport that may be associated with improved performance. Therefore, this investigation examined the exercise training patterns and anthropometric characteristics between Novice and Expert amateur motorcycle road racers. Novice amateur racers are defined as racers who have attended a motorcycle racing school and received a racing competition license. Expert amateur racers are defined as racers who have finished in the top three in any of their classes at the Grand National Finals and/or in the top five in points in any class in any region as a "novice" rider. The data may provide valuable insight into how exercise training may be associated with motorcycle road racing performance in Novice and Expert amateurs, and this may influence recommendations for exercise training to improve motorcycle road racing performance.

1.2 RATIONALE AND SIGNIFICANCE

Exercise is an important component in preparing for competition. Failure to properly train for a competitive sport can lead to performance decrements, fatigue and injury (Davey, Throrpe & Williams, 2002; Stone, 1990; Hewett, Lindenfeld, Riccobene & Noyes, 1999). Through the implementation of appropriate exercise training programs, athletes can improve body composition, muscular strength and endurance, ligament and bone integrity for injury prevention, the efficiency of the metabolic energy systems, cardiorespiratory fitness, and other physiological parameters that may be important for athletic performance (Kraemer et al., 1996; Deschenes & Kraemer, 2002). However, exercise programs may need to be tailored to the specific needs of the individual athlete and the physiological and biomechanical demands of a particular sport to significantly improve athletic performance.

Investigations have been conducted to identify characteristics of athletes in particular sports. These descriptive studies show that physiological characteristics may differ between athletes within a given sport as well as differ between athletes across different sports. For example, Pincivero and Bompa (1997) reported differences in the characteristics of athletes participating in different positions within American football. It was shown that offensive backs, defensive backs and wide receivers tend to display the lowest percentages of body fat, lower absolute strength scores, fastest times over 5-, 10-, 40- and 300 meters (m), and the highest relative maximal oxygen uptake compared to athletes at other positions. Offensive and defensive linemen tend to be generally larger, have higher levels of percent body fat and greater absolute strength scores. These characteristics may coincide with the demands of the particular position, and identifying position specific characteristics may influence the development of exercise programs based on the requirements of the specific position.

Reilly, Bangsbo and Franks (2000) focused on anthropometric and physiological characteristics of elite soccer players. Midfield players and fullbacks had the highest maximal oxygen uptake; however, midfield players tended to have the lowest muscle strength. S. Gil, J. Gil, A. Irazusta, Ruiz and J. Irazusta (2007) examined young non-elite soccer players and reported that forwards were the leanest and performed the best in certain physiological tests (endurance, velocity, agility and power), whereas goalkeepers were found to be the largest in stature, possess the highest body weight and percent body fat, and the lowest aerobic capacity.

In a study of elite women rugby players, Gabbett (2007) reported that individuals playing forward positions had higher body weight and skinfold thickness, slower running speed, and lower muscular power, glycolytic capacity, and estimated maximal aerobic power when compared to individuals playing back positions. These studies may support the need to develop sport-specific and position-specific exercise programs to optimize athletic performance.

Sport-specific exercise programs have been developed based on characteristics shown to be involved in sport-specific performance. For example, Lephart et al. (2005) developed an eight-week golf-specific exercise program based on previously identified characteristics involved in improved play. The exercise program resulted in improved golf-specific strength, flexibility and balance, and this may have contributed to improved golf performance. Murlasits and Langley (2002) detailed an in-season training for high school football, and Szymanski and Frederick (2001) detailed a periodized speed program for baseball players. Barrett et al. (2007) developed a strength and conditioning program for bull riding based on the various movements, injuries and physiological stresses in the sport, and Everline (2007) detailed a periodized strength and conditioning program for shortboard performance surfing. Exercise training programs for other sports have been developed based on identified characteristics specific to the performance needs of those particular sports (T. Burger & M. Burger, 2006; Judge, 2007; Jones & Bampouras, 2007; Gamble, 2006; Marques et al., 2006).

Investigations characterizing motorcycle riders have been limited to off-road motorcycling. In a study by Gobbi et al. (2005), researchers examined the physiological characteristics of top level off-road motorcyclists (i.e. motocross, enduro and desert rally). Assessments included BMI, body fat percentage and maximal aerobic capacity. Motocross, enduro and desert rally racers had BMI's of 23.7 kg/m^2, 24.5 kg/m^2 and 25.7 kg/m^2, respectively.

Body fat percentages of motocross, enduro and desert rally racers were 13.3%, 12.6% and 15.1%, respectively. Maximal aerobic capacity, assessed on a cycle ergometer, elicited values of 57.5 ml/kg/min for motocross racers, 49.5 ml/kg/min for enduro racers and 49.1 ml/kg/min for desert rally racers. Konttinen, Kyrolainen & Hakkinen (2008) examined BMI and aerobic capacities of Finnish A-level (competitive) and hobby motocross cross riders. The competitive racers had a mean BMI of 22 kg/m^2 and hobby riders had a mean BMI of 24 kg/m^2. Maximal aerobic capacities of competitive and hobby riders were 49 ml/kg/min and 43 ml/kg/min, respectively. Burr, Jamnik, Shaw & Gledhill (2010) reported habitual recreational off road motorcycle riders to have maximal aerobic capacities of 43.3 ml/kg/min. The investigators also assessed VO_2 while riding off-road motorcycles and discovered a mean value of 21.3 ml/kg/min. Off-road motorcyclists were riding at 51.3% of the VO_{2max} during riding while eliciting an average heart rate of 141.3 beats per minute (bpm).

Collins, Doherty and Talbot (1993) suggested that psycho-emotional stress is associated with riding a motorcycle due to the extremely high level of required concentration. And it has been demonstrated that endurance training can reduce psycho-emotional stress and increase psychological capacity and stress tolerance (Schwaberger, 1987). Endurance training can also improve fatigue resistance and body composition (Powers & Howley, 2004). Maintaining an appropriate body mass (i.e. weight) can be beneficial to a motorcycle racer because being overweight in motorsports is unfavorable. It overloads the bike as well as provides extra mass that must be accelerated (and decelerated during braking). Therefore, the heavier rider requires more muscular force for optimal control of the motorcycle (Gobbi et al. 2005). It has also been suggested that fatigue in motocross is due mainly to the static involvement of several muscle groups congruent with the jumping and landing movements. This fatigue produces a decrease in the muscular force necessary to oppose acceleration and deceleration forces during a race and is one of the human factors that may limit performance in motor sports and therefore, must be considered in sport conditioning (Gobbi et al. 2005).

Despite theses investigations of off-road motorcycling, there still exists a dearth of information concerning the physiological and anthropometric characteristics of motorcycle road racing. The available scientific literature pertaining to motorcycle road racing is limited to identification of the types of physical injuries sustained by athletes participating in this sport (Tomida et al. 2005). Albeit motocross and motorcycle road racing are different motorcycle riding endeavors, the sport provides the greatest similarity for comparison. Investigations have demonstrated off-road motorcycling to be physically demanding The information provided by the aforementioned investigations of off-road motorcycling suggests that weight, BMI, aerobic capacity and muscular strength and endurance appear to be components of motorcycle riding performance. Therefore, this investigation focused on examining the exercise training patterns and anthropometric characteristics between Novice and Expert amateur motorcycle road racers. If the current study reveals that particular characteristics are associated with Novice and Expert amateur motorcycle road racers, exercise training programs can be developed to enhance those specific characteristics. This information will be valuable in the development of exercise programs specific to motorcycle road racers.

1.3 SPECIFIC AIMS AND RESEARCH HYPOTHESIS

The aim of this study was to characterize amateur motorcycle road racers and examine if different specific exercise training patterns and/or anthropometric characteristics exist between Novice and Expert amateur motorcycle road racers. The specific aims and hypotheses examined in this investigation included the following:

1. To compare differences in body mass index between novice and expert amateur motorcycle road racers. It was hypothesized that body mass index would be lower in expert amateur motorcycle road racers compared to novice amateur motorcycle road racers.

2. To compare differences in estimated cardiorespiratory fitness between novice and expert amateur motorcycle road racers. It was hypothesized that estimated cardiorespiratory fitness would be higher in expert amateur motorcycle road racers compared to novice amateur motorcycle road racers.

3. To compare differences in total physical activity between novice and expert amateur motorcycle road racers. It was hypothesized that total physical activity would be higher in expert amateur motorcycle road racers compared to novice amateur motorcycle road racers.

4. To compare differences in upper body resistance exercise training patterns between novice and expert amateur motorcycle road racers. It was hypothesized that upper body resistance exercise training patterns would be different between expert amateur motorcycle road racers and novice amateur motorcycle road racers.

5. To compare differences in lower body resistance exercise training patterns between novice and expert amateur motorcycle road racers. It was hypothesized that lower body resistance exercise training patterns would be different between expert amateur motorcycle road racers and novice amateur motorcycle road racers.

6. To compare differences in aerobic exercise training patterns between novice and expert amateur motorcycle road racers. It was hypothesized that aerobic exercise training patterns would be different between expert amateur motorcycle road racers and novice amateur motorcycle road racers.

2.0 REVIEW OF LITERATURE

2.1 INTRODUCTION

There is a body of scientific literature that has shown the importance of sport-specific characteristics that may be linked to improved performance in a variety of sports and athletic events. Moreover, based on these findings, sport-specific exercise training programs have been developed to enhance athletic performance. A sport that is increasing in popularity is amateur motorcycle road racing. However, little is known about the physiological and performance characteristics of amateur athletes participating in motorcycle road racing, and therefore, there is a lack of data on which to base exercise training programs that are specific to this sport. Therefore, the primary aim of this study was to characterize amateur motorcycle road racers and to examine if specific exercise training patterns and/or anthropometric characteristics are associated with improved motorcycle road racing performance. The following is a review of related scientific literature related to this topic area that was used to inform the design of this current study.

2.2 PHYSIOLOGICAL CHARACTERISTICS ASSOCIATED WITH SPORT-SPECIFIC PERFORMANCE

Investigations have been conducted to identify characteristics of athletes in particular sports. These descriptive studies show that physiological characteristics may differ between athletes within a given sport as well as differ between athletes across different sports. The following briefly describe the associations observed between physiological parameters and specific athletic requirements of athletes.

2.2.1 Off-road Motorcycling

Gobbi et al. (2005) examined the physiological characteristics of top level off-road motorcycle riders who participate in motocross, enduro or desert rally races. The investigation conducted assessments of body mass index, body composition, maximal aerobic power, knee extensor and flexor isokinetic and isometric strength, elbow extensor and flexor isokinetic and isometric strength, and hand grip strength. Body composition was assessed by an anthropometric method (description not given) and BMI was calculated from height and weight. Maximal aerobic power (VO_{2max}) was measured using both arm and leg incremental tests. The leg test encompassed a Monark cycle ergometer starting at 60 W with increments of 30 W every 3 minutes until exhaustion. The arm test encompassed a Monark arm cycling ergometer starting at 19 W with increments of 19 W every 3 minutes until exhaustion. Maximal aerobic power was measured using an open circuit method. The expired air was collected at the last minute of the test in a Douglas bag and the gas concentrations were determined using a paramagnetic oxygen analyzer. Isokinetic and isometric strength assessment encompassed measuring maximum peak torque on an isokinetic dynamometer at angular speeds of $0^o sec^{-1}$ and $60^o sec^{-1}$. Maximum right and left handgrip isometric force was measured with a mechanical handgrip dynamometer.

The results of the investigation revealed body mass indicies of motocross, enduro and desert rally racers to be 23.7 kg/m^2, 24.5 kg/m^2 and 25.7 kg/m^2, respectively. Assessment of body compositions showed motocross, enduro and desert rally racers to have body fat percentages of 13.3%, 12.6% and 15.1%, respectively. Maximal aerobic capacities of motocross, enduro and desert rally racers were 57.5 ml/kg/min, 49.5 ml/kg/min and 49.1 ml/kg/min, respectively. Isokinetic and isometric strength outcomes are located in Table1 and Table 2.

Table 1 Maximum Peak Torque (Nm) of knee flexors and extensors of both right and lefts limbs

Racers	ISOMETRIC ($0^o sec^{-1}$)				ISOKINETIC ($60^o Ssec^{-1}$)			
	Knee Flexors		Knee Extensors		Knee Flexors		Knee Extensors	
	Right	Left	Right	Left	Right	Left	Right	Left
Moto	277	266	167	146	222	199	141	135
Enduro	251	253	172	160	211	203	145	145
Desert	236	221	185	161	198	193	152	158

Table 2 Maximum **Peak Torque (Nm) of elbow flexors and extensor of both right and left limbs**

Racers	ISOMETRIC (0ºsec^{-1})				ISOKINETIC (60ºSsec^{-1})			
	Elbow Flexors		Elbow Extensors		Elbow Flexors		Elbow Extensors	
	Right	Left	Right	Left	Right	Left	Right	Left
Moto	110	107	96	100	71	75	78	81
Enduro	94	92	88	87	77	76	73	72
Desert	83	88	83	85	73	71	77	73

Maximum right and left handgrip isometric forces of motocross, enduro and desert rally racers were 511 N and 545 N, 506 N and 506 N, and 500 N and 499 N, respectively. The investigators also recorded heart rate (HR), with a heart rate recorder during an international competition and blood lactate concentration within 2 minutes of the end of the race by taking a microsample of arterialized blood form the ear lobe and immediately analyzing it. Heart rate values during the race for motocross, enduro and desert rally racers ranged between 180 to 200 bpm, 180 to 195 bpm and 100 to 150 bpm, respectively. Blood lactate concentration at the end of the race had values of 5.3 mM, 3.8 mM and 1.1 mM, for motocross, enduro and desert rally racers, respectively. The observed lactate value in motocross suggests there is an anaerobic component to riding a motorcycle in competition. The results of this investigation indicate that there are differences between off-road motorcycle racers. These observed differences may reflect the varying physical demands of motocross, enduro and desert rally racing.

Burr et al. (2010) examined habitual recreational off-road motorcyclists. Seventy three habitual recreational off-road motorcycle riders participated in the study. Maximal oxygen consumption was assessed via open-circuit spirometry on a treadmill of increasing speed and elevation. The mean VO_{2max} of the group was 43.3 ml/kg/min. Cardiorespiratory demand of off-road riding was also assessed. The participants wore an ambulatory oxygen consumption analyzer for one twenty-minute lap. The average time to complete the 9.4km lap was 24.2 minutes. The mean VO_2 requirement while riding was 21.3 ml/kg/min. Muscular strength and power were assessed before and after riding. Upper body push and pull strengths were assessed using a specifically designed isometric spring resisted device, which allowed for quantification of both push and strengths at a standardized elbow joint angle of 110º. Push and pull strengths decreased by 4.2 kg and 2.6 kg, respectively. It should be noted that the participants in the current study were not competitive racers. Therefore, the reported values may not reflect the performance characteristics of an elite or professional motocross racer. However, the current study does contribute to the literature of motorcycle riding and the possible characteristics that are involved.

Konttinen et al. (2008) examined physiological responses of 12 motocross racers (7 Finnish A-level "competitive" and 5 "hobby") that included measurements of VO_{2max}, BMI and blood lactate levels. The body mass indicies of competitive and hobby riders were 22 kg/m^2 and 24 kg/m^2, respectively. Maximal aerobic capacity was assessed Monark cycle ergometer using an incremental loading protocol with 2-minute stages at a neutral pedaling rate of 60-100rpm. Each subject began pedaling at a load of 50 W, which was increased by 30 W every 2 minutes until exhaustion. Competitive riders had a VO_{2max} of 49 ml/kg/min whereas hobby riders had a VO_{2max} of 43 ml/kg/min.

Subjects rode an off-road circuit at maximal speed for approximately 30 minutes. Cardiorespiratory responses, heart rate, blood lactate levels were recorded. The average HR during riding was 181 bpm and 185 bpm, for competitive and hobby riders respectively. Blood lactate levels were recorded after each third lap with a finger tip blood sample. Blood lactate levels of competitive riders had values of 4.0, 4.4 and 4.2 $mmol \cdot L^{-1}$ and hobby riders had values of 5.7, 4.9, and 4.6 $mmol \cdot L^{-1}$. The investigators contributed the stable blood lactate values of competitive riders to their greater riding economy at maximum speeds compared to hobby riders. The VO_2 of competitive riders while riding decreased from 42 ml/kg/min, to 37 ml/kg/min, to 34 ml/kg/min whereas the VO_2 of hobby riders decreased from 39 ml/kg/min to 37 ml/kg/min to 34 ml/kg/min. This investigation provides further insight into the physical demands of motocross riding. Furthermore, it demonstrated differences in physiological responses between competitive and hobby riders. The differences observed in this investigation provide evidence that sport conditioning may be beneficial to the competitive motorcycle racer.

Ascensao, Azevedo, Ferreira, Oliveira, Marques and Magalhaes (2008) examined the physiological, biochemical and functional changes of off-road competitive motocross racers. The investigation included measurements of VO_{2max}, HR_{max}, blood lactate concentration, an arm Wingate anaerobic test, Rate of Perceived Exertion (RPE) and catecholamines. Participants underwent three simulated competitive races within two weeks in a 1.5 km typical motocross circuit. Maximal oxygen consumption was assessed on an incremental treadmill test, with speeds increasing by 0.2 m/s every minute until exhaustion. The test yielded a mean $V0_{2max}$ value of 53.5 ml/kg/min and a mean HRmax of 198.3 bpm. The HR profile of riders during the simulated race indicated that 87% of the riding time was spent above 90% of $HR_{max.}$ Wingate anaerobic tests were performed before and 5 minutes within the end of the competitive ride. The test used a

Monark mechanical braked and friction loaded cycle ergometer. The test yielded a mean Peak power of 7.5 $W \cdot kg^{-1}$ and a mean power of 5.2 $W \cdot kg^{-1}$. Post-race results of the Wingate test elicited a reduction in mean peak power (7.5 to 6.9 $W \cdot kg^{-1}$) and mean power (5.2 to 4.8 $W \cdot kg^{-1}$). Blood lactate values were collected at the 10^{th} and 20^{th} minute of the ride as well as immediately after. Capillary blood lactate concentration increased significantly from rest to 10 minutes (~5.3 mM), 20 minutes (~4.1 mM) and post-race (~3.8 mM). There was also a significant increase in the 24-hr urine catecholamine (adrenaline and noradrenalin) concentration after the race when compared to resting values (exact values were not reported). The rate of perceived exertion on the Borg scale for the 3 races was 17, 18.1 and 18.6, respectively.

The aforementioned investigations indicate a physical component to motocross riding. The research shows increased heart rates, anaerobic metabolism, reduction in strength/power from baseline to post race, and RPE scores of "very hard." As mentioned previously, motocross racing and motorcycle road are different racing endeavors. Motocross racing is characterized by off-road closed, racing circuits, either man-made or natural, that consists of high jumps, irregular terrain, dirt, mud and sharp turns. Motorcycle road racing is characterized by paved, closed, racing circuits consisting of elevation changes, multiple turns and motorcycles reaching significantly greater speeds. However, research in motocross provides the greatest similarity for which to compare data and speculate the possible performance characteristics of motorcycle road racing.

2.2.2 American Football

Pincivero and Bompa (1997) reported differences in the characteristics of athletes participating in different positions within American football. Offensive backs, defensive backs and wide receivers (i.e. skill positions) tend to display the lowest percentages of body fat when compared to offensive and defensive linemen. Offensive backs, defensive backs and wide receivers had body fat percentages of 12.4, 11.5 and 12.4, respectively; whereas, offensive linemen and defensive linemen had body fat percentages of 19.1 and 18.5, respectively.

Offensive backs, defensive backs and wide receivers tend to display lower absolute strength scores when compared to offensive and defensive linemen. Offensive backs, defensive backs and wide receivers had 1 repetition maximum (RM) bench presses of 115.7 kg, 132.2 kg and 122.9 kg, respectively; whereas, offensive and defensive linemen had 1 RM bench presses of 162.2 kg and 159.7 kg, respectively. Similar findings were discovered in the 1 RM squat. Offensive backs, defensive backs and wide receivers had squats of 188.5 kg, 174.2 kg and 168 kg, respectively; whereas, offensive and defensive linemen had squats of 216.8 kg and 207.5 kg, respectively.

There were also differences observed for speed and aerobic capacity. For example, offensive backs, defensive backs and wide receivers had the fastest times over 5-, 10-, 40- and 300 meters, when compared to offensive and defensive linemen. For instance, offensive backs, defensive backs and wide receivers had 40 yard dash times of 4.81 seconds, 4.58 seconds and 4.58 seconds, respectively; whereas, offensive and defensive linemen had 40 yard dash times of 5.08 seconds. Offensive backs, defensive backs and wide receivers had relative maximal oxygen uptake (VO_{2max}) values of 52.4, 54.5 and 52.4 ml/kg/min, respectively. Defensive linemen had VO_{2max} values of 43.5 ml/kg/min. These characteristics may coincide with the demands of particular positions, and identifying position specific characteristics may influence the development of training programs based on the requirements of the specific position.

2.2.3 Soccer

Gil et al. (2007) examined the physiological and anthropometric characteristics of young non-elite soccer players. The investigation conducted an Astrand cycle ergometer test for the estimation of VO_{2max}, an endurance test on a 400 meter athletic track consisting of 6 repetitions of 800 meters at an increasing pace with a 1 minute recovery between repetitions, a 30 meter sprint test to estimate velocity, a 30 meter sprint test with cones to estimate agility and a jump test to estimate explosive power. Anthropometric measurements consisted of height, weight and tricep, subscapular, abdominal, suprailial, thigh and lower leg skinfolds. Body mass index (BMI) was calculated from weight (in kg) and height (in m^2). Forwards had a body fat percentage of 10.95, whereas goalkeepers had a body fat percentage of 12.22. Goalkeepers had a VO_{2max} of 48.41 ml/kg/min whereas forwards, midfielders, and defenders had VO_{2max} values 62.4, 57.71 and 58.55 ml/kg/min, respectively.

These physiological and anthropometric differences reflect the physiological workload of the respective position. Forwards performed the best in the Astrand test, the endurance test, and the velocity, agility and jumping test. It was noted that agility and power of the lower extremities were most important characteristics to forwards whereas height, agility, and endurance were the most important characteristics to midfielders. The physiological workloads of goalkeepers are markedly different from the outfield players. Thus, goalkeepers, in this study, were heavier, slower, and possessed less athletic ability compared to other positions. However, improved body composition, endurance and athletic ability may improve a goalkeeper's performance.

2.2.4 Ice Hockey

In an investigation by Agre, Casal, Leon, McNally, Baxter and Serfass (1988), VO_{2max}, body composition, muscle strength and flexibility was assessed in twenty-seven National Hockey League (NHL) players. Height, weight and body composition measurements were collected for anthropometric data. Cardiorespiratory fitness was assessed using the Bruce protocol treadmill graded exercise test. Flexibility was assessed via a sit-and-reach test, forehead-to-knee test, goniometer measurements of the hip adductors and abductors. Strength of the hip adductors was measured isometrically (the authors failed to give a detailed description). Three 5 second isometric efforts, with 1 minute rests in between, were obtained. The strength of the internal and external shoulder rotator muscles and knee flexor and extensor muscles were measured isokinetically at an angular velocity of 30°/sec on a Cybex dynamometer. Three maximal efforts of internal and external shoulder rotation and knee flexion and extension were performed.

The hockey players weighed an average of 85.6 kg with 9.2% body fat (goalies = 8.7%, forwards = 7.7%, defensemen =12.2% body fat). There were no significant differences in VO_{2max} between goalies, forwards and defensemen (53.1, 54.2 and 52.2 ml/kg/min, respectively). Goalies had 8 degrees more Range of Motion (ROM) (53°) in hip abduction than forwards (44°) and defensemen (45°), and this may reflect that goalies need to have greater flexibility due to their positional roles involving positioning their body to prevent opponents from scoring.

There were no significant differences for measures of strength between the positions. The players averaged 241 and 239 Newton meters, respectively, for right and left knee extension at

30°/sec. In measurement of right and left knee flexion at 30°/sec, the players averaged 143 and 137 Newton meters, respectively. In measurement of right and left internal shoulder rotation at 30°/sec the players averaged 70 and 67 Newton meters, respectively. In measurement of right and left external shoulder rotation at 30°/sec, the players averaged 44 and 43 Newton meters, respectively.

Some of these findings differ from results reported by Twist and Rhodes (1993) in which investigators assessed thirty-one NHL players. In this investigation VO_{2max} values for goalies, forwards and defensemen were 49.1, 57.4 and 54.8 ml/kg/min, respectively. Defensemen were markedly stronger than goalies in maximal repetitions of 200 lbs in the bench press (defensemen = 14.3 reps, goalies = 4.3 reps, forwards = 12.0 reps). However, consistent with Agre et al. (1988), goalies had greater ROM than defensemen and forwards.

2.2.5 Rugby

In a study by Gabbett (2007), muscular power, speed, agility, glycolytic capacity and maximal aerobic power of elite women rugby players were examined. Height, body mass and skinfold thickness were collected for anthropometric data. Lower body muscular power was estimated by means of a vertical jump test. Speed was evaluated with a 10-, 20- and 40 meter sprint effort. Agility was evaluated using the 505 agility test. Glycolytic capacity was estimated with a test that lasted approximately 45 – 60 seconds and used a series of forward, backward, and lateral movements on a 40 x 20 meter course. The players were instructed to complete the course as quickly as possible. Maximal aerobic power was estimated via a multistage fitness test where players were instructed to run back and forth along a 20 m track, keeping in time with a series of signals on a compact disc.

Physiological and anthropometric differences were found between positions. Forwards were heavier, had greater skinfold thickness, and had lower 10-, 20- and 40 meter speed, muscular power, glycolytic capacity, and estimated maximal aerobic power compared to backs. Forwards had a body mass of 75.5 kg, whereas backs had a body mass of 64.7 kg. Forwards' skinfold summation was 141.2, whereas backs' skinfold summation was 114.8. Backs ran a 1.94 sec in 10 meter sprints, whereas forwards ran a 2.06 sec in the 10 meter sprint. In the 20 meter sprint, forwards ran a 3.65 sec sprint, whereas backs ran a 3.40 sec sprint. In the 40 meter sprint, forwards ran a 6.70 sec sprint, whereas backs ran a 6.22 sec sprint. Backs had significantly higher vertical jumps (37.0 cm) compared to forwards (34.3 cm). Forwards had significantly lower glycolytic agility (53.5 sec) compared to backs (51.2 sec). Forwards also had significantly lower maximal aerobic power (31.2 ml/kg/min) compared to backs (34.5 ml/kg/min). The physiological demands of the particular position were reflected in the results; suggesting that different positions encompass different workloads during play.

2.2.6 Basketball

Ostojic, Mazic and Dikic (2006) investigated the structural and functional characteristics of sixty elite Serbian basketball players. The authors divided the players into categories respective to their playing position (guards, forwards and centers). A series of tests were conducted to assess height, weight, body fat percentage, estimated VO_{2max}, vertical jump height and vertical jump power. Body fat was assessed using skin fold calipers at seven cites. Vertical jump height was assessed via a computer connected to a force platform that calculated jump height from the time the subject was off the mat. The calculation of jump height assumed that the takeoff and landing positions of the body's center of gravity were the same. The subjects were asked to keep their hands on the hips to prevent arms from contributing to the jump. Vertical jump height was normalized to standing height and body mass. Vertical jump power was calculated using a formula. (This formula was not described.) Maximal oxygen uptake was indirectly obtained using a multi-stage 20 m shuttle run test. (This test was not described.)

The results of the test revealed that a relationship exists between positional roles and particular characteristics. Centers were taller than forwards and guards (207.6 cm, 200.2 cm and 190.7 cm, respectively). Centers were heavier than forwards and guards (105.1 kg, 95.7 kg and 88.6 kg, respectively). Centers also had a lower estimated VO_{2max} compared to forwards and guards (46.3, 50.7 and 52.5 ml/kg/min, respectively). Vertical jump height was not statistically different between centers, forwards and guards (54.6, 57.8 and 59.7 cm, respectively) however, due to centers' greater body mass, vertical jump power was statistically different (centers = 1,683.0 W, forwards = 1,578.6 W and guards = 1,484.9 W). Further perspective of the results reveal that the guards were shorter, weighed less, had higher VO_{2max} values, had lower vertical jump height values (albeit not statistically different), and had less vertical jump power than centers and forwards. This investigation further supports the notion that within particular sports there exist characteristics that vary between positional roles. Once again, this is speculated to be a result of the responsibilities of the specific role during game play. Guards are responsible for bringing the ball up the court quickly and moving around the perimeter of the basket whereas centers are responsible for play close to the basket. Hence, centers are taller and weigh more to be close to the rim and move opponents away from the rim and guards weigh less to allow them to move quickly around the court.

2.2.7 Tennis

Davey et al. (2002) examined fatigue in eighteen tennis players. The investigator sought to determine the effect of fatigue induced by maximal tennis hitting upon skilled tennis performance. The players performed a skill test before and immediately after a fatigue inducing tennis test. The skill test was designed to assess accuracy in groundstrokes and service. A target was placed in the left and right rear singles court and a tennis ball serving machine fed balls to players alternating from the forehand (10 balls) to the backhand (10 balls) at a frequency of 15 balls per minute. The players were requested to aim their returns to the right rear singles court target. After the 20 fed tennis balls, the players repeated the test, attempting to hit the target in the left rear singles court. For assessing accuracy of service strokes, a target was placed at the end portion of the right service box aligned with the service line. The players attempted to serve balls (10) into the target area at match pace. This procedure was repeated for the left service court. The fatigue inducing Loughborough Intermittent Tennis Test consisted of 4-minute bouts of maximal tennis hitting with 40 second seated recovery between bouts until volitional fatigue. Players were required to hit returns (30 per minute via ball feeding machine) at maximum effort towards the targets in the rear singles court. Fatigue was acknowledged when the required hitting frequency was not maintained for two consecutive feeds from the tennis ball serving machine or when players stopped voluntarily. Results showed that groundstroke hitting accuracy decreased by 69% from start to volitional fatigue in the intermittent tennis test. Service accuracy also declined by 30% after the intermittent tennis test.

2.2.8 Baseball

Tripp, Yochem and Uhi (2007) examined the effect of functional fatigue on upper extremity sensorimotor system acuity in college baseball throwers. The sensorimotor system is responsible for providing the awareness, coordination, and feedback to joints for reproducing motions and stability. The investigators used an electromagnetic tracking device with motion software to test active multijoint position reproduction acuity. Sensors were applied to the subjects and digital creations of the subjects were used to map the motions of anatomical segments involved in throwing. The subjects were then tested on the ability to reproduce their arm cocked and ball release positions to identify individual throwing motions. With the initial positions established as the target positions, subjects were instructed to recreate the positions during three trials. Trials consisted of the target position and three attempts to recreate the position with the subjects being blindfolded. The three trials were completed within 20 seconds. The investigators then induced functional fatigue. The functional fatigue protocol consisted of a single bout of throwing baseballs at a target located 20 feet away. Subjects were instructed to throw at maximal velocity and accuracy every 5 seconds. Subjects were considered fatigued when they reported an exertion level exceeding 14 on a Borg scale or after 160 throws. Immediately after the functional fatigue protocol, subjects repeated the three trials of recreating the arm cocked and ball release positions.

Results showed that fatigue decreased sensorimotor system acuity in the arm cocked position for the scapulothoracic, glenohumeral, and elbow joints. For recreation of the ball release position, fatigue significantly decreased sensorimotor system acuity for each joint. Reduced acuity can lead to joint proprioceptive deficits, functional instability, injury and compromised structural stability. Decreasing sensorimotor system acuity hampered the ability of college baseball throwers to reproduce proper throwing form.

2.3 EXAMPLES OF SPORT-SPECIFIC CONDITIONING PROGRAMS

Sport conditioning coaches, exercise physiologists and athletic trainers alike, have developed and/or implemented specific training programs for specific sports attempting to give their athletes an “edge” over their competitors. Sport specific training programs induce physiological adaptations relative to the specific sport. Thus, training is more effective and time efficient. Furthermore, as an athlete begins to adapt to the stresses of training, there is a greater need to employ specific training regimens to continue producing physiological adaptations (Judge, Moreau & Burke, 2003; Kraemer & Ratamess, 2005, Kraemer et al., 1996). For instance, if an untrained person begins an exercise program, the induced adaptations will enhance his or her functional capacity independently of the type of exercise. A swimming conditioning program will also improve running and cycling performance capacities because of general physiological adaptations (i.e. increase stoke volume, decreased heart rate, improved arterial – venous oxygen difference, etc.). However, for elite athletes who have undergone the general physiological adaptations, training needs to be highly specific to the sport for which the athlete is training to improve performance.

2.3.1 Softball

Terbizan, Waldera, Seljevold and Schweigert (1996) measured the changes in response to a 16-week softball conditioning program of nine fastpitch amateur adult league softball players. The investigation consisted of pre- and post-testing of cardiovascular fitness, anaerobic power, body composition, flexibility and grip strength. Cardiovascular fitness (VO_{2max}) was assessed using the Bruce protocol. Maximum aerobic power was determined when the subject could no longer continue, or when physiological measures no longer continued to increase. A Wingate test was used to measure anaerobic power for the legs and arms. Body weight determined the specific workload of the 30 sec maximum test. Body fat percentage was assessed via hydrostatic weighing. Flexibility of the hamstring and lower back, shoulder and back was measured via the sit and reach test, the shoulder lift test and the trunk extension test, respectively. Hand and forearm strength was measured using a grip strength test with a hand dynamometer. Both hands were tested twice and the greatest strength was recorded for both hands. Muscle strength was measured using weight machines. The subjects' 10 RM weight was used to calculate 1 RM measures. The maximum weight the subject could lift correctly 10 times was considered to be her 10 RM. The measured exercises consisted of the bicep curl, shoulder pullover, shoulder press, tricep extension, latissimus pull down, leg extension, leg flexion and leg press.

The 16-week conditioning program was designed to improve physiological profiles related to softball. Subjects completed the training on their own and reported training logs to the researchers every 2 weeks to account for compliance and researchers made suggestions regarding modifications to improve workouts. Flexibility specific to softball was encouraged to be completed twice a day as well as before and after any training. Aerobic conditioning consisted of walking, jogging or running to improve cardiovascular capacity. Subjects were encouraged to work toward being able to jog a continuous 1 mile course midway into the program. Strength training consisted of exercises similar to the tested lifts. Subjects completed 3 to 4 sets of 6-10 RM. Starting resistance was based on the individuals calculated 1RM. Weeks 12 to 16 were dedicated to anaerobic training. Twenty to 100 yard sprints to simulate base running was used for training. Training consisted of 10 reps with 30 – 45 second rest periods.

Training resulted in improvements in aerobic capacity, anaerobic power, body composition and muscle strength. Aerobic capacity increased from 36.07 ml/kg/min to 38.30 ml/kg/min however, the measures were not statistically significant. Anaerobic power improved from 263.88 W to 282.24 W in the arms and from 391.80 W to 405.97 W in the legs, albeit the improvement in the legs was not statistically significant. Body fat percentage was lowered significantly from 28.31 to 24.14 after training. Hand grip improved significantly in non-dominant grip from 29.81 kg to 38.38 kg. Muscle strength improved significantly in the following exercises: bicep curl from 45.91 kg to 58.92 kg, tricep extension from 27.20 kg to 31.96 kg, shoulder pullover from 36.72 kg to 51.69, latissimus pull down from 44.21 kg to 51.69 kg, shoulder press from 22.78 kg to 36.73 kg, leg extension from 48.63 kg to 76.18 kg and leg curl from 34.68 kg to 48.29 kg. The leg press did not improve significantly (116.31 kg to 123.45 kg). It was noted that the leg press was not available to all subjects during their training.

2.3.2 Golf

Lephart et al. (2005) developed an 8-week golf-specific exercise program based on previously identified characteristics involved in improved play; such as, hip abduction strength, torso rotation strength, shoulder horizontal abduction/adduction, shoulder extension, hip flexion/extension, knee-extension range of motion and single leg balance. Subjects of varying golf experience participated in an 8-week conditioning program.

Kinematic data of the golf swing for each golfer were collected for biomechanical analysis. Golf ball launch data were collected via a system that uses a microphone to determine club to ball impact and a high-speed camera to record 2 images of the ball after impact. The system also measured ball velocity, launch angle, backspin rate, club head velocity, carry distance, and total distance. Each golfer used his own driver and the same driver was used for each testing session. Data were collected for 10 shots from each golfer. Torso, shoulder, and hip muscle strength was assessed with a Biodex multijoint system. Peak torque was normalized for each subject. Torso strength assessment consisted of subjects performing left and right torso rotations for 5 repetitions at 60°/sec and 10 repetitions at 120°/sec. There was a 1 minute rest between the 2 speeds. Shoulder testing consisted of moving the shoulder from an internal rotation starting position to an external rotation position. The subjects performed 5 maximal repetitions at 60°/sec, and 10 repetitions at 180°/sec with a 1 minute rest period between the 2 speeds. To assess hip abduction, subjects were in a side-lying position and performed 3 isometric contractions with the dynamometer resistance adapter. To assess hip adduction, subjects were placed at 20º of hip adduction in the side-lying position and performed 3 isometric contractions. Balance was assessed using a force plate. Subjects were asked to perform single-leg standing balance test for each leg under 2 conditions (eyes open and eyes closed). Three 10 second trials were collected for each condition. Shoulder, hip, and torso rotation ROM was assessed using a standard goniometer.

The 8-week conditioning program consisted of stretching exercises, strengthening exercises and balancing exercises. Subjects exercised 3 – 4 days per week performing 3 sets of 10 – 15 repetitions with elastic resistance tubing. The program was designed to enhance those characteristics proven to be involved in improved play. The conditioning program led to significant improvements in left torso strength at 60°/sec (pre: 136.4, post: 149.7 peak torque/body weight), right torso strength at 60°/sec (pre: 137.1, post: 148.3 peak torque/body weight), right torso strength at 120°/sec (pre: 125.0, post: 144.1 peak torque/body weight), left hip abduction isometric strength (pre: 135.2, post: 148.0 peak torque/body weight) and right hip abduction isometric strength (pre: 134.3, post: 149.1 peak torque/body weight). Statistically significant improvements were made in all ROM tests. Significant improvements were observed in anterior-posterior sway on the left side in eyes-open and eyes-closed conditions and medial-lateral sway on the right side in eyes-open condition. Club velocity, ball velocity, carry distance and total distance were significantly increased from 42.4 to 44.7, 60.7 m/s to 64.0 m/s, 193.7 m to 209.8 m, and 207.4 m to 222.5 m, respectively. Thus, the sport conditioning program was effective in improving the characteristics known to be involved in improved play.

2.3.3 Baseball

Bat swing velocity has been identified to significantly contribute to improved baseball batting and torso rotational strength is a key factor in improving swing velocity. Biomechanic, cinematographic and electromyographic studies have demonstrated that batting is a sequence of coordinated muscle activity connected together by 3 body segments (i.e. hips, torso, and arms). It was suggested that in order to improve bat swing velocity, strength training should emphasize multijoint leg exercises and explosive hip and torso rotational strength. Therefore, Szymanski et al. (2007) developed a 12-week sport-specific conditioning program designed to improve angular hip (AHV), angular shoulder (ASV), linear bat-end and hand velocities (HV), and 3 RM torso rotational and sequential hip-torso-arm rotational strength to examine the effect of torso rotational strength on linear bat velocity.

The investigators recruited fifty-five high school baseball players for pre- and post-testing of height, body mass, body composition, AHV, ASV, BEV, HV, 3 RM dominant and non-dominant torso rotational strength, medicine ball hitter’s throw and 3 RM parallel squat and bench press. The bat swing protocol consisted of 2 sets of 10 warm-up swings with an 83.8 cm, 851 g baseball bat. After the warm-up, participants had reflective markers attached to their body for bat swing testing via motion capture software. The hitter performed 10 swings (4 practice and 6 recorded) at the batting tee station of hitting the baseball into the catch net. The hitter had 20 seconds of rest between swings.

Motion capture software was utilized to record and measure AVH, ASV, linear BEV and HV. Torso rotational strength was assessed using a Cybex Torso Rotational Machine. Participants performed a 3 RM torso rotational strength test for their dominant side first (i.e. bat swing side) then the non-dominant side. The participants performed a torso rotation that was similar to the range of motion of a bat swing. A 1kg, 2-handed medicine ball hitter's throw test for maximum distance was used to assess sequential hip-torso-arm rotational strength. Participants were instructed to stand in their normal game batting stance, holding the medicine ball at their back shoulder height with 2 hands behind a taped line. They were then asked to throw the medicine ball (similar to the movement of their normal bat swing) for maximum distance. The subject was allotted 2 practice trials and 3 maximal efforts. The best distance in meters was recorded. Parallel squat and bench press assessment used Olympic standard free weights. An estimation of 1 RM was determined by performing 3 RM tests (i.e. the maximal amount of weight lifted 3 times). There were 3 minutes of rest between near maximal lifts. The 1 RM was estimated using a load assessment table.

The participants were randomly assigned to 1 of 2 training groups; Group 1 performed resistance exercises and Group 2 performed resistance exercises and sport-specific medicine ball exercises. Group 1 and Group 2 performed resistance training 3 days a week for a periodized 12 weeks. Five sets of 10 repetitions of parallel squats and bench press were performed. Additionally, stiff leg dead-lifts, dumbbell rows, shoulder presses, biceps curls, and triceps extensions were performed. Group 2 additionally performed medicine ball exercises 3 days a week for 12 weeks (2 days of baseball movements, 1 day of whole body, explosive exercises). Baseball movement medicine ball exercises consisted of exercises that mimicked the sequential, ballistic, and rotational movements of hitting and throwing a baseball.

After 12 weeks of training, Group 2 showed greater improvements in linear bat-end velocity, angular hip velocity, angular shoulder velocity, 3 RM dominant and non-dominant torso rotational strength, and medicine ball hitter's throw than Group 1. Group 2 improved BEV by 6.4%, whereas Group 1 improved only by 3.6%. Group 2 improved HV by 3.6%, whereas Group 1 improved only by 2.6. Group 2 improved dominant and non-dominant torso rotational strength by 17.1% and 18.3%, respectively, whereas Group 1 only improved 10.5% and 10.2%, respectively. Group 2 improved the medicine ball hitter's throw by 10.6% whereas Group 1 only improved 3.0%. Group 2 increased AHV 6.8% and ASV 8.8%, whereas Group 1 made no improvements in AHV and ASV. This investigation not only supports the notion that sport conditioning improves performance but that greater specificity may produce greater improvements.

In a study by Lachowetz, Evon and Pastiglione (1998), investigators examined the effect of strength training on baseball throwing velocity in college baseball players. Throwing velocity, in combination with accuracy, is a performance characteristic in baseball. The investigators sought to improve this performance characteristic via an 8-week upper body strength training program consisting of: flat bench press, triceps pushdowns, latissimus pull downs, bicep curls, lateral rows, internal shoulder rotation, external shoulder rotation, horizontal shoulder abduction, horizontal shoulder adduction and shoulder extensions. Twenty-two college baseball players were either assigned to a control group or a strength training group. The strength training group trained 4 days per week, performing 6 exercises on Mondays and Thursdays, 5 exercises on Tuesdays and Fridays. In the first week, 3 sets of 10 RM for every exercise were performed with a 2 minute rest period between sets. In weeks 2 through 8, the 10th repetition of the 3rd set of each exercise was immediately followed by 5 assisted repetitions with a spotter. The control group did not participate in any strength training. However, both groups participated in a throwing program 3 times a week consisting of 15 minutes of long tossing at a distance of approximately 76 m, and 20 – 25 maximal effort throws at a distance of 27 m.

Maximum throwing velocity was measured over a distance 18.44 m via a Sports radar gun. After warm-up, players performed 5 pitches at maximum effort with up to 30 seconds of rest between pitches. Both the control group and the strength training group were tested prior to and after the 8-weeks. One repetition maximum for all 11 exercises was calculated from a 10 RM protocol in week 1 and week 8 for both groups.

Following the 8 weeks of training, the strength training group improved their throwing velocity up to 5.25 mph whereas the control group throwing velocity declined. Additionally, strength increased 37.1% for the strength training group and only 8.05% for the control group when averaged for the percent changes in all 11 exercises.

2.3.4 Swimming

In sprint swimming, upper body limb strength and speed have been identified as the physiological parameters while the technical parameters have been identified as stroke rate and stroke length. Girold, Calmels, Maurin, Milhau and Chatard (2006) examined the effect of assisted (overspeed training) and resisted (overstrength) sprint training on those physiological and technical parameters identified as performance characteristics in swimming. Thirty-seven competitive-level swimmers were assigned to one of three groups (assisted training, resisted training or a control). All swimmers trained 6 days per week for 3 weeks, including 3 assisted or resisted training sessions per week for the sport specific training groups, respectively. The control group did not participate in sport specific training. The overstrength group swam 6 all out 30 second front crawl sprints with a 30 second recovery period between each sprint. The swimmers were tethered to the starting platform with a 5 meter long elastic surgical tube. The tube stretched out over an average distance of 15 meters. The overspeed group was tethered using an 8-meter elastic tube attached to the point of arrival. The departure point was 25 meters away and the elastic tube pulled the swimmer to the point of arrival. The swimmers were instructed to follow the speed given by the elastic by having a high stroke rate and trying not to decrease their distance per stroke. Between each sprint, the swimmer got out of the pool, walked back to the point of departure, and jumped into the water. The exercise session duration was about 6 minutes, which was similar to the duration of the overstrength exercise session.

An isokinetic dynamometer was used to assess flexion-extension peak torque, expressed in newton-meters (N·m), of the 2 forearms before the training and after week 2 and week 3 of training. Measurements were made at 60°/sec and 180°/sec concentrically and at 0°/sec isometrically. The subjects performed 2 maximal efforts with 3 repetitions alternating flexion and extension at 60°/sec and 180º/sec. A 30 second rest period separated each effort, and a 2 minute rest period separated each velocity. For isometric measurement, subjects performed 2 maximal efforts in flexion and extension at an elbow angle of 90º. The efforts lasted 5 seconds with a 3 minute rest period between repetitions. Swimming performance was measured before training and at week 2 and week 3 during a 100 m front crawl competition. The stroke rate, expressed as the number of strokes per minute, was measured twice every 50 m, using a stroke base 3 stopwatch. The distance per stroke was calculated by dividing the mean velocity of each 50 m by the mean stroke rate.

The sport-specific training (i.e. overstrength training) resulted in greater improvements in swimming parameters compared to standard training. The overstrength group made significant strength gains from pre-training values in concentric flexion at 60º/sec (9.1 N·m) and 180º/sec (15.3 N·m), and isometric extension 0°/sec (24.9 N·m). The control group (standard training) only made significant strength gains from pre-training values in isometric flexion at 0°/sec (16.8 N·m). The overstrength group exhibited a 2% increase in 100 m performance compared to –0.3% for the control group. Both the overstrength and overspeed groups significantly increased stroke rate to 43.01 cycle/min^{-1} and 43.47 cycle/min^{-1} respectively; whereas, the control group had no significant gains. Hence, sport-specific conditioning proved to be more effective than the traditional training program in improving swimming-related strength parameters, swimming performance and stroke rate.

2.3.5 Volleyball

Mihalik, Libby, Battaglini and McMurray (2008) studied the effect of complex and compound training on vertical jump height and lower body power production. Vertical jump height and lower body power production is an important performance characteristic in volleyball. The investigators recruited 11 men and 20 women from a Division I club volleyball program and divided them into either a compound training group or a complex training group. Complex training alternates between resistance exercises and biomechanically similar plyometric exercises within a single exercise session. Compound training involves performing resistance exercise and plyometric exercise in separate sessions. Men and women were divided into the two groups by gender matching them on pre-training vertical jump height (VJH).

Vertical jump testing was conducted in pre-training and after week 1, 2, 3, and 4 of training. Subjects performed a vertical jump on a force platform using countermovement, with an arm swing, reaching up and striking the highest possible marker of a Vertec measuring device and landing back on the force platform. Subjects performed 3 maximal vertical jumps with 3 minute rest periods between each jump. Power was estimated from an equation involving the subject's mass (kg) and VJH measurement (cm).

The volleyball players trained twice a week for 4 weeks. The complex group completed both plyometric and resistance training exercises on each day, while the compound group completed resistance exercise and plyometric exercise on separate days. Resistance exercise was composed of squats, single leg lunges, and deadlifts. Subjects performed 3 sets of 6 repetitions at 60% of his or her 1 RM. Plyometric exercise was composed of 3 sets of 6 repetitions of depth jumps, split squat jumps, and double leg bounds. Rest periods lasted 60 seconds between sets and 2 minutes between individual exercises.

Both the complex and the compound group were able to improve VJH and lower body power output. The complex training group increased their VJH from 48.2 cm to 50.9 cm (~5.4%), while the compound training group increased their VJH from 47.8 cm to 52.6 cm (~9.1%). The complex training group increased their lower body mean power output from 3865 W to 4060 W (~4.8%), while the compound training group increased from 3765 W to 4072 W (~7.5%). Thus, this investigation supports the concept that sport conditioning can improve performance characteristics to which it is designed to enhance.

The aforementioned investigations (Luebbers et al., 2003; Mihalik et al., 2008; Trappe & Pearson, 1994; Girold et al., 2007; Lachowetz et al., 1998) add to the literature that sport conditioning leads to improved performance and that sport specific conditioning has greater effects on performance.

2.4 ADDITIONAL EVIDENCE TO SUPPORT SPORTS CONDITIONING PROGRAMS

Murlasits and Langley (2002) detailed an in-season training program for high school football, which provided examples of a 4-day off-season conditioning program, an in-season conditioning program as well as appropriate testing battery to assess progress. Szymanski and Frederick (2001) detailed a periodized speed program for baseball players. In addition, there is evidence of exercise training programs for lacrosse, distance running, javelin throwing and volleyball (T. Burger & M. Burger, 2006; Judge, 2007; Jones & Bampouras, 2007; Gamble, 2006b; Marques, Gonzalez-Badillo & Kluka, 2006).

Exercise training programs have been developed for less popular American sports as well. For example, Barrett et al. (2007) developed the strength and conditioning program for bull riding. Based on the various movements, injuries and physiological stresses in the sport, the investigator developed a periodized strength and conditioning schedule for participants. Everline (2007) detailed a periodized strength and conditioning program for shortboard performance surfing, and provided an analysis of shortboard surfing maneuvers and injuries and developed an exercise training program based on those analyses. Sturgess and Newton (2008) designed a specific strength program for badminton players based on the characteristics of the sport. Behm

(2007) developed a periodized training program for an Olympic curling team based on physical attributes known to improve curling performance.

2.5 PHYSIOLOGICAL RATIONALE FOR SPORT-SPECIFIC TRAINING

The study of exercise physiology has demonstrated that when the human body is exposed to a stimulus (e.g. exercise, physical exertion, training etc.), it adapts physiologically and anatomically to the imposed demands (Kraemer et al. 1996). These adaptations have been proven to be beneficial to one's overall health by reducing a number a cardiovascular risk factors and improving functional capacity via biochemical adaptations within the musculoskeletal system (ACSM, 1998; Kraemer & Ratamess, 2005). Exercise has been extensively demonstrated to improve maximal oxygen consumption, body composition, muscle strength, muscle endurance and many other biochemical and physiological parameters within the human body (Powers & Howley, 2004; Baechle & Earle, 2000). These benefits have not only provided the impetus for exercise promotion but have become the reason why exercise is an imperative component of competitive sport preparation.

Activity-specific conditioning may have its roots in periods of World War when soldiers exercised to improve their performance on the battlefield (Delorme & Watkins, 1948). Today, sport conditioning is the cornerstone of many athletes' preparation for competition in which athletes train specifically to enhance their performance in their chosen sport. The probability of transferring the effects of training to athletic performance is highly dependent on the degree to which training replicates athletic performance (Gamble 2006a; Kraemer, 1985). For example, the movement, musculoskeletal action and stresses, and the primary energy system must be similar to the sport for which the athlete is training to optimize the effect on performance.

Research in exercise physiology has demonstrated that not only are there general physiological and anatomical adaptations, but these adaptations are highly specific to the type and mode of training. For example, skeletal muscle has been demonstrated to be highly pliable to specific resistance exercise combinations of intensity, number of sets, number of repetitions and rest period lengths (ACSM, 2002; Kraemer et al., 1996; Wernbom et al., 2007). Campos et al. (2002) examined thirty-two untrained men who participated in an 8-week progressive resistance training program. Subjects were assigned to one of four groups: 1) a low repetition group performing 3-5 RM for 4 sets with 3 minutes of rest between sets of exercises, 2) an intermediate repetition group performing 9-11 RM for three sets with 2 minutes rest, 3) a high repetition group performing 20-28 RM for two sets with 1 minute rest, and 4) a non-exercising control group. For each set, the training subjects performed repetitions until failure. Three exercises were performed 2 days per week for the first 4 weeks and 3 days per week for the final 4 weeks. Maximal strength improved the greatest in the low repetition group, whereas the maximal number of repetitions at 60% 1 RM improved the greatest in the high repetition group. The study also assessed skeletal muscle fiber hypertrophy and revealed that significant hypertrophy adaptations only occurred in the low and intermediate repetition groups where the resistance load was a greater percentage of 1 RM. The data in this study and other investigations (Aagaard, Simonsen, Trolle, Bangsbo & Klausen, 1996; Harris, Stone, O'Bryant, Proulx & Johnson, 2000; Kawamori & Haff, 2004) support the notion that physiological adaptations in skeletal muscle are linked to the intensity, number of sets, number of repetitions, and rest period lengths of resistance training sessions. Thus, there exists a "strength–endurance continuum" that must be employed in a sport-specific exercise training program to produce the desired outcomes relative to a particular sport.

Also contributing to specific adaptations in skeletal muscle is the velocity of the muscle contraction of the exercised muscle. In a study by Kanehisa and Miyashita (1983), twenty-one male subjects were tested pre- and post-training for maximal knee extension power at five specific speeds with an isokinetic dynamometer. Subjects trained the knee extensors by performing 10 maximal voluntary contractions in the slow velocity group, 30 in the intermediate velocity group and 50 in the fast velocity group 6 times per week for 8 weeks. The fast velocity group showed gains in strength only at the faster speeds, whereas the slow velocity group exhibited the greatest gains in strength at slower speeds. Thus, research has demonstrated that velocity of training influences muscular strength and power gains.

Research has demonstrated that adaptations in energy metabolism are also specific to the imposed demands of exercise. Tabata et al. (1996) conducted two training experiments using a mechanically braked cycle ergometer. The first experiment examined the effect of 6 weeks of moderate-intensity endurance exercise (70% of VO_{2max}, 60 min/day, 5 days/week) on anaerobic capacity. The second experiment examined the effects of 6 weeks of high-intensity intermittent training on energy release. The high-intensity training consisted of seven to eight sets of 20 second exercise bouts at an intensity of about 170% VO_{2max} with a 10 second rest period between each bout. The results of the first experiment showed that aerobic training improved VO_{2max} by 5 ml/kg/min but had no significant effect on anaerobic capacity. However, in the second experiment, high-intensity exhaustive exercise improved anaerobic capacity by 28%. The investigators suggested the reason the endurance training experiment did not have an effect on anaerobic capacity was due to the lack of significant stress on the anaerobic energy releasing system. This investigation further supports the concept that physiological adaptations are specific to the imposed demands of exercise.

The results from these studies suggest that there is a need to match training programs to the sport-specific needs of athletes. For example, the training program for sport performance that requires explosive muscular power may be substantially different than training for sport performance that requires longer duration aerobic fitness. Thus, it is critically important to first establish the sport-specific physiological characteristics prior to the development and implementation of sport-specific training programs that are targeted to enhance athletic performance.

Sport conditioning has been shown to reduce the occurrence of injury (Verrall, Slavotinek & Barnes, 2005). Stone (1990) suggested that many of the injuries to the muscle system involve connective tissue such as tendons, ligaments and the muscle sheaths. Therefore, it was suggested that proper conditioning, particularly resistive training, which strengthen muscle and connective tissue, might result in fewer injuries of this nature (Kubo, Kanehisa, Miyatani, Tachi & Gukunaga, 2003). This is supported by a prospective study conducted by Hewett et al. (1999) in which the investigators monitored two groups of female soccer, volleyball and basketball athletes during 1 school year or one sport season. One group participated in a 6-week preseason neuromuscular training program before the sport season and the other group did not train. The trained group was composed of 366 female athletes who were trained in jumping and landing techniques designed to increase vertical height and increase strength before the sport season. The training sessions lasted between 60 and 90 minutes a day on alternating days. The 6-week training program consisted of three, 2-week phases. The first 2-week phase demonstrated and drilled proper jump techniques for wall jumps, tuck jumps, broad jumps, squat jumps, double-legged cone jumps, 180º jumps and bounding in place. Each jump exercise session lasted between 10 to 30 seconds depending on the particular exercise. Phase two concentrated on building a base of power, strength and agility. Phase two consisted of wall jumps (30s), tuck jumps (30s), jump, jump, jump, vertical jump (5-8 reps) squat jumps (20s), bounding for distance (1-2 runs), double-legged cone jumps (30s/30s), scissor jumps (30s) and hop, hop, stick landing (5 reps/leg). Phase three concentrated on gaining maximum vertical jump height. Phase three consisted of wall jumps (30s), step, jump up, down, vertical (5-10 reps), mattress jumps (30s/30s), single-legged jumps distance (5 reps/leg), squat jumps (25s), jump into bounding (3- 4 runs), hop, hop, stick landing (5 reps/leg). One to two minutes of recovery time was allotted between each exercise. Weight training was performed after jump training with a 15 minute rest period. Weight training consisted of trunk exercises, upper body exercises and lower body exercises (leg press and calf raise). Each exercise was performed for 1 set of 12 repetitions for upper body exercises and 15 repetitions for trunk and lower body exercises.

A decrease incidence of knee injury in female soccer, volleyball and basketball athletes was noted after a neuromuscular (plyometric) training program. The untrained group demonstrated an injury rate 3.6 times higher than the trained group. Studies by Cahill and Griffith (1978) and Hejna, Rosenberg, Buturusis and Krieger (1982) also demonstrated that muscle strengthening reduces the number of injuries in football, basketball, gymnastics, volleyball and wrestling.

Cahill and Griffith (1978) examined the incidence of football knee injuries over an 8-year period. The first four years in which no pre-season conditioning occurred (non-conditioning group) were compared to years five to eight in which pre-season conditioning was employed (conditioning group). The conditioning program emphasized total body conditioning through cardiovascular exercise, acclimatization to heat, weight training, flexibility drills, and agility exercises over a 5- to 6-week period, 3 days a week for 80 minutes. The participants were high school varsity football players.

A knee injury was defined as one severe enough to cause the athlete to miss, or not fully participate in, two consecutive practice sessions or a practice session and a game. There were 135 knee injuries that occurred in 2,480 athletes during the eight-year period. Eighty-five of the injuries occurred in the non-conditioning group, whereas 50 occurred in the conditioning group. There was a 63% reduction in knee injuries requiring surgery and a 35% reduction in the number of knee injuries not requiring surgery in the conditioning group compared to the non-conditioning group. The results of the investigation support the conclusion that conditioning can reduce the number of injuries sustained in athletes.

Henja et al. (1982) also examined the effects of strength training on injury prevention. The investigators recruited high school athletes participating in basketball, football, gymnastics, volleyball and wrestling to participate in the study. The athletes were assigned to one of three groups; Group 1 resistance trained during the pre-season and competitive season only (moderate), Group 2 resistance trained year-round (maximum) and a third group did not utilize resistance training as part of their training program, or participated once per week or less during the competitive season (control). Each athlete was given a training program suited to his or her position and /or sport. While not described in detail, the investigators noted that a combination of diversified variable resistance isokinetic and isotonic exercises were utilized for each athlete.

The investigators calculated the injury rate of each group during their respective competitive season. Injury rate was calculated as the number of injuries reported for a given group divided by the number of subjects in the group. An injury was defined as a medical problem resulting from athletic participation necessitating removal from a practice or competitive event and/or resulting in missing a subsequent practice or competitive event. Two-hundred thirty two athletes participated in moderate or maximum resistance training programs. The boys who participated in maximum resistance training had an injury rate of 32.94%, whereas the moderate resistance training group and control group had injury rates of 37.50% and 79.10%, respectively. The female athletes who participated in maximum resistance training had an injury rate of 13.3%, whereas the moderate resistance training group and control group had injury rates of 18.5% and 20%, respectively. Hence, year-round conditioning appeared to mitigate the number of injuries suffered during the competitive season. Even resistance training during the pre-season and competitive season only, reduced the number of injuries suffered by athletes compared to those who had little or no weight training.

2.6 SUMMARY

Based on the review of literature, it appears that sport-specific exercise training programs can be of tremendous benefit to a variety of athletes. However, prior to development and implementation of sport-specific training programs, it is important to determine the characteristics and needs of athletes in particular sports. The available literature on off-road motorcycle riding provides the greatest similarity to motorcycle road racing physical demands. The physical demands of off-road motorcycling have been demonstrated in several investigations (Gobbi et al., 2005; Konttinen et al., 2008, Burr et al., 2010). These investigations suggest that weight, BMI, aerobic capacity and muscular strength and endurance appear to be components of motorcycle riding performance.

While there is available research for a variety of sports, there are limited data available on motorcycle road racers. The review of the available scientific literature revealed that the only studies conducted on motorcycle road racers have been limited to identification of the types of physical injuries sustained by athletes participating in this sport (Tomida et al., 2005). However, no scientific literature was identified that characterized the physiological parameters associated with improved performance in this sport. Therefore, this study was designed to conduct an initial study of body mass index, cardiorespiratory fitness and exercise training patterns of motorcycle road racers that may be associated with improved performance. If characteristics can be identified that are associated with enhanced performance in this sport, additional research will be conducted to determine the extent to which sport-specific exercise training programs improve these characteristics and whether this improvement also translates to an improvement in performance in this sport.

3.0 METHODS

3.1 INTRODUCTION

Exercise training programs for sports have grown in popularity, as athletes desire to maximize their performances. There is a plethora of information concerning exercise training patterns for the more popular American sports such as football, basketball and baseball. Much less information has been published concerning non-dynamic sports such as motor sports. Individuals participating in motor sports exert a great amount of energy counteracting acceleration and braking forces (Gobbi et al., 2005). However, motorcycle road racing has yet to have any published research concerning the physical attributes of these athletes and whether exercise training programs will affect their performance. Therefore, the purpose of this study was to examine the exercise training patterns and anthropometric characteristics between Novice and Expert motorcycle road racers and to ascertain what characteristics may be associated with amateur motorcycle road racing performance.

3.2 SUBJECTS

The investigation recruited 53 subjects from individuals who participated in Western Eastern Roadracing Association (WERA) Sportsman Series racing events. Subject demographics are shown in table 3. The following inclusion criterion was used to determine if individuals were eligible to participate in the investigation.

1. Eligible subjects were ≥ 18 years of age.
2. Eligible participants participated in 2010 WERA Sportsman Series racing events.

Table 3 Subject demographics

Demographic	Novice	Expert
# of subjects	32	21
Male	30	20
Female	2	1
Mean Height (in)	69.95 ±2.86	70.02 ±3.12
Mean Weight (lbs)	180.13 ±30.73	166.33 ±21.53
Mean Age	34.81 ±8.57	37.33 ±10.22

3.3 RECRUITMENT PROCEDURES

Recruitment postings were placed on WERA's on-line forum and motorcycle track day organization forums to alert racers who could be eligible for this study. The postings instructed potential subjects to visit a website to view further information on the investigation and complete an online survey. Postings were placed on the forums weekly until an adequate sample size was obtained or four months had elapsed from the time of the initial posting.

The names of the racers who met the inclusion criteria were available electronically online at www.mylaps.com. This website provides the names of racers, lap times, dates, and tracks of all WERA racing events. This website was used to identify the racers who participated in 2010 WERA Sportsman Series racing events.

3.4 EXPERIMENTAL DESIGN AND PROCEDURES

This study used a cross-sectional design to examine the specific aims and to test the hypotheses of this study. Participants who consented to participate in this study completed a survey that provided information to examine the specific aims of this study. This survey was administered electronically via an online survey tool (e.g., Survey Monkey, etc.). The informed consent was given online. Participants were required to give their electronic consent in the form of their name and electronic mail address to continue onto the survey. The participant was instructed to answer all questions as accurately as possible and to not skip any questions. If a participant decided to not complete the survey once started, he/she could exit the survey at any time without submitting the completed responses. The survey did not permit participants to 'save' and 're-enter' the survey once they had exited. If a participant had to exit the survey, he/she had to start at the beginning if he/she chose to complete it at another time. In the case where an individual did not have access to the online survey a paper copy of the survey was mailed to the subject. This survey was then returned to the investigator via mail. Participants were informed that they were to complete the entire survey to receive the honorarium for participating in this study.

3.5 SELF-REPORT HEART RATE

In order to estimate cardiorespiratory fitness, a measure of resting heart rate was required. Participants were instructed to manually assess their resting heart rates prior to initiating the on-line survey. The instructions read as follows:

Assessing your resting heart rate involves you locating your wrist (radial) pulse or neck (carotid) pulse and counting the number of beats that occur in a 60 second time span. You will need a digital watch or a clock with a second hand to assess your resting heart rate. The measurement of resting heart rate should be taken after a few minutes upon waking while still lying in bed. Give your body some time to adjust to the change from sleeping before taking your pulse (2-5 minutes). If you are not able to take a measurement first thing in the morning, make sure you lie down for at least 10 minutes before taking the measurement. It is ideal to practice the following techniques to ascertain which technique is easiest for you and to improve accuracy. Once you have chosen your desired technique, practice taking your pulse for two separate 30 second intervals. After your two practice measurements, proceed to measure your resting heart rate with your chosen technique.

For a wrist (radial) pulse measurement, use the tips of your index and middle finger. The wrist pulse (radial artery) can be found on the thumb side of either wrist. It lies just a little below the base of the thumb. The pulsing will be felt when the fingers are in the right place. Hold gently. After locating the pulse, do not remove your fingertips. Look at your digital watch or clock with a second hand and begin your count with "zero" on the starting time mark; then count the pulses for 60 seconds. Write your resting heart rate down so you don't forget. You will need to remember this number when completing the online survey.

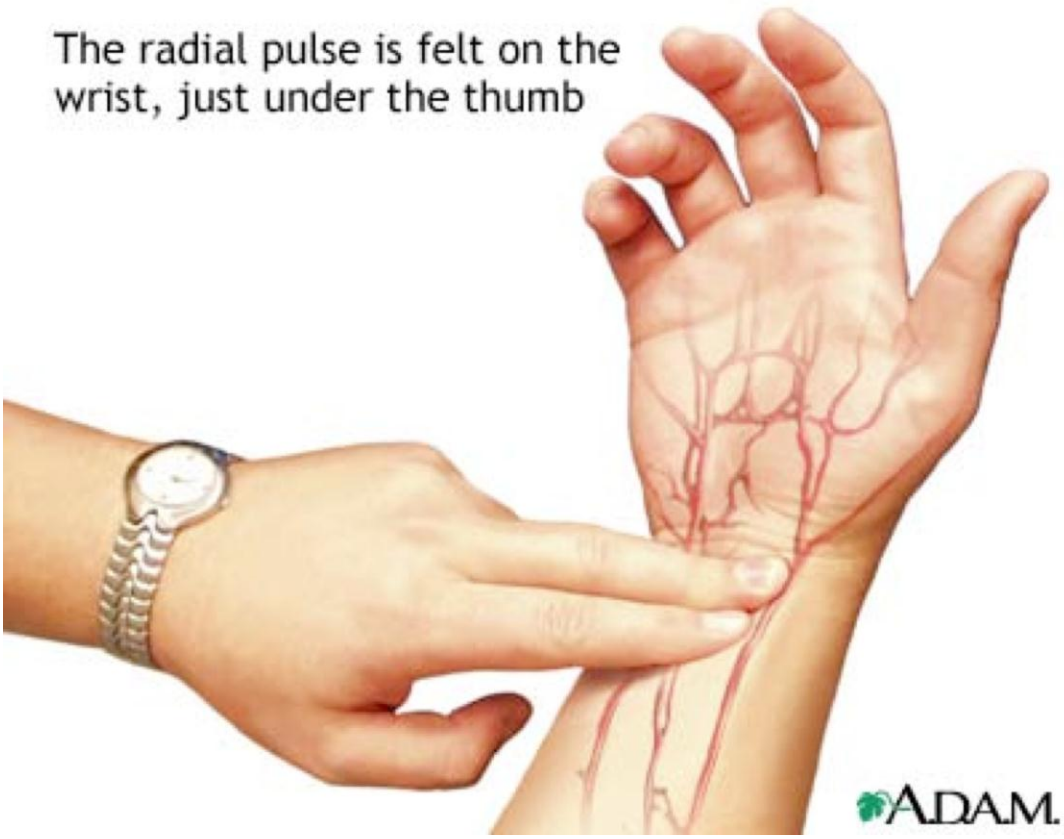

Figure 1 Radial Pulse Detection illustration

(photo retrieved from American Accreditation HealthCare Commission (http://www.urac.org))

The neck (carotid) pulse measurement is taken in a place just below the jaw along the windpipe and along the throat. Use the fingertips of the index and middle fingers to press gently. Do not move your fingers around in a massaging motion while trying to find your carotid pulse or press too hard. This can lower your blood pressure and cause dizziness. After locating the pulse, do not remove your fingertips. Look at your digital watch or clock with a second hand and begin your count with "zero" on the starting time mark; then count the pulses for 60 seconds. Write your resting heart rate down so you don't forget. You will need to remember this number when completing the online survey

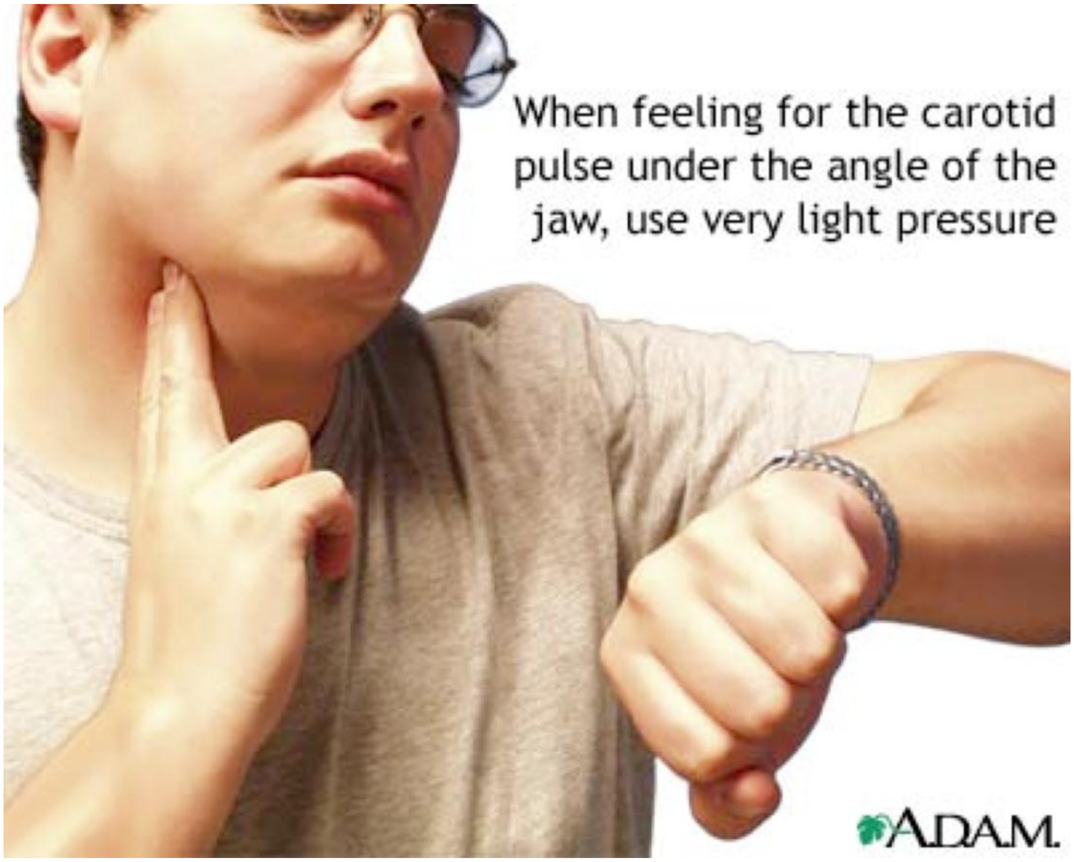

Figure 2 Carotid Pulse Detection Illustration

(photo retrieved from American Accreditation HealthCare Commission (http://www.urac.org))

Validity of the palpation technique to assess heart rate has been investigated. Pollock et al. (1972) showed no significant difference between subject and telemetry (audiocount) and /or ECG heart rate counts measured post-exercise. Mean differences were less than 2% with the subject palpation mean 170.1 bpm (SD = 10.5) and telemetry 169.4 bpm (SD = 8.9). DeVan et al. (2004) showed that pulse rate obtained via carotid and radial palpation following exercise at 70% heart rate maximum was no different from heart rate measured with ECG after exercise. At 70% heart rate maximum, radial palpation and ECG were ~108 bpm and ~110 bpm, respectively. Carotid palpation and ECG at 70% heart rate maximum were ~110 bpm and ~117 bpm, respectively. These investigations provide evidence that the palpation technique is a viable tool in accurately assessing heart rate.

3.6 OUTCOME ASSESSMENTS

3.6.1 Body Mass Index

Body mass index was calculated from self-reported height and weight. Height was converted from inches to centimeters using the following equation: inches x 2.54 = cm. Weight was converted from pounds to kilograms using the following equation: pounds x .454 = kg. Height (cm) and weight (kg) were inserted into the following equation to calculate subjects' BMI. mass (kg) / height^2 (m^2) = BMI.

Self-reported height and weight validity and reliability have been investigated. Studies indicate that there is a common trend to slightly over-report height and under-report weight; however, self-reported height and weight have been found to be a valid measure to estimate BMI (Avila-Funes, Gutierrez-Robledo, & Ponce De Leon Rosales, 2004; Huber, 2007; M. Kuczmarski, R. Kuczmarski & Najjar, 2001). Spencer, Appleby, Davey and Key (2001) compared self-reported values to measurements assessed by a nurse following a standard protocol. Spearman Rank Correlations between self-reported and measured height, weight, and BMI were high ($r > 0.9$). Ninety percent of the values of self-reported height were within -3 and +5 cm of the measured value. Ninety percent of the values of self-reported weight were within -6 and +1.5 kg of the measured value. Kuczmarski et al. (2001) compared self-reported data to measured height and weight in adults in the Third National Health and Nutrition Examination Survey. The study revealed a high correlation between self-reported data and measured height.

The correlations measured and self-reported height ranged from 0.85 to 0.93 for men and 0.77 to 0.93 for women. Huber (2007) compared self-reported height and weight measurements to measurements obtained by trained nursing assistants. Results showed that women tended to underestimate their weight by 4.6 pounds (SE: 0.61) and overestimate their height by 0.1 inches (SE: 0.06). The author concluded that self-reported height and weight measurements provide an accurate representation of measured height and weight.

3.6.2 Total Physical Activity

The Global Physical Activity Questionnaire (GPAQ) (Appendix A) was used to collect data. It was developed by the World Health Organization (WHO) for physical activity surveillance in different countries. It collects information on physical activity participation in three settings and sedentary behavior. The three settings are activity at work, travel to and from places and recreational activities.

The development of the GPAQ involved extracting questions from the short- and long-version of the International Physical Activity Questionnaire (IPAQ), an instrument with known acceptable-to-good validity and reliability (Craig et al., 2003) and suggestions from experts within the WHO. The World Health Organization subsequently coordinated research to test the reliability and validity of the GPAQ in nine countries. The test-retest reliability of GPAQ was examined over multiple applications using a 3- to 7-day time gap. Validity was examined by comparing GPAQ with IPAQ. Validity of GPAQ was further assessed using motion sensors (i.e. pedometers or accelerometers). Results from the motion sensors indicated a fair correlation (r=0.31) for total physical activity. Validity results between the GPAQ and IPAQ showed a moderate-to-good correlation coefficient (r=0.54) for total activity. Test-retest reliability data produced good-to-excellent results (0.67-0.81) (Armstrong & Bull, 2006). The Global Physical Activity Questionnaire has been found to be comparable to the validity and reliability of the IPAQ. Furthermore, the GPAQ provides a less limited and complex structure than the International Physical Activity Questionnaire.

3.6.3 Estimated Cardiorespiratory Fitness

A non-exercise test model (Appendix B) was utilized to estimate maximal oxygen consumption. Non-exercise test models estimate maximal oxygen consumption from the regression of measured maximal oxygen uptake on independent variables known to be predictive of maximal oxygen consumption such as gender, age, body mass index, resting heart rate (RHR), and self-reported habitual physical activity levels. Respondents received instructions on how to self-assess RHR. The non-exercise test model estimated maximal METs, which was used to calculate maximal oxygen consumption. The following equation was used to calculate maximal oxygen consumption: 1 MET = 3.5 ml of O_2/kg of body mass/min.

Non-exercise test models to estimate maximal oxygen consumption have been proven to provide reasonable validity (George, Stone & Burdett, 1997; Jackson & Blair, 1990; Willford, Sccharff-Olson, Wang, Blassing, Smith & Duey, 1996). In study by Jurca et al. (2005), investigators sought to extend a previous non-exercise test model for estimating cardiorespiratory fitness. Secondary analysis was performed on data previously obtained on three large cohorts of adults. In all three databases, gender, age, BMI, resting heart rate, and self-reported physical activity levels were recorded. Additionally, either a maximal or submaximal treadmill test was preformed to assess cardiorespiratory fitness. The investigators used multiple linear regression to develop a non-exercise prediction model for each database. Pearson productmoment correlations were used to examine the relationship between maximal METs estimated from the regression equation and the criterion measure of cardiorespiratory fitness within each database. The standard estimate of error ranged from 1.45 METS to 1.97 METs. Based upon these results, the investigators concluded that gender, age, BMI, resting heart rate and self-reported physical activity habits can provide a good estimate of cardiorespiratory fitness.

The non-exercise prediction model, which elicited a standard estimate of error of 1.45 METS, also elicited the highest cross-correlations. This non-exercise prediction model can be found in Appendix B and was used to assess cardiorespiratory fitness for recruited subjects.

3.6.4 Exercise Training Patterns

A supplemental questionnaire (Appendix C) collected data relative to motorcycle racing, such as racing experience and sponsorship, and exercise training patterns. Exercise training patterns were collected for upper body resistance training patterns, lower body resistance training patterns and aerobic exercise patterns.

3.7 STATISTICS

All data analysis was conducted using SPSS statistical software. Brown-Forsythe tests for homogeneity of variance were performed on BMI, weight, cardiorespiratory fitness and total physical activity. Shapiro-Wilk tests for normality were performed on BMI, weight, cardiorespiratory fitness and total physical activity. To compare Novice and Expert amateur motorcycle racers on normally distributed outcome variables, independent t-tests were performed

(BMI and cardiorespiratory fitness). To compare Novice and Expert amateur motorcycle racers on non-normally distributed outcome variables, Mann-Whitney U tests were performed (total physical activity, recreational physical activity and weight). To analyze weight, BMI and estimated cardiorespiratory fitness among novices who participated and did not participate in resistance exercise, independent sample t-tests were performed. To analyze weight, BMI and estimated cardiorespiratory fitness among experts who participated and did not participate in resistance exercise, independent sample t-tests were performed. To analyze weight, BMI and estimated cardiorespiratory fitness among novices who participated and did not participate in aerobic exercise, independent sample t-tests were performed. To analyze weight, BMI and estimated cardiorespiratory fitness among experts who participated and did not participate in aerobic exercise, independent sample t-tests were performed. A Cross-tabulation was used to analyze frequency distributions of aerobic and resistance exercise participation of novice and expert amateur motorcycle road racers. Pearson Chi-square tests were performed to reveal differences between novice and expert amateur motorcycle road racers in aerobic and resistance exercise participation, aerobic exercise frequency and duration, resistance exercise frequency and resistance exercise selection. Novice Amateur racers were defined as racers who attended a motorcycle racing school and received a racing competition license. Expert Amateur racers were defined as racers who finished in the top three in any of their classes at the Grand National Finals and/or in the top five in points in any class in any region as a “novice” rider. The variables that were compared between these two categories of racers were body mass index, weight, estimated cardiorespiratory fitness, total physical activity, recreational activity, aerobic exercise training patterns and resistance exercise training patterns. Differences between groups were defined at $p \leq 0.05$.

The computer program G*Power was used to conduct a power analysis. G*Power is a free, completely interactive, menu-driven program for IBM-compatible and Apple Macintosh personal computers. It performs high-precision statistical power analyses for the most common statistical tests in behavioral research, that is, t tests, F tests, and X^2 tests (Erdfelder, Faul & Buckner, 1996). G*Power was utilized to compute sample sizes for a given effect size, alpha levels, and power values (a priori power analyses). The presented investigation required a sample size of 144 subjects for a medium effect size (d= .5) and a sample size of 58 subjects for a large effect size (d=.8). The investigation was able to recruit 53 participants (novice = 32, experts = 21).

4.0 RESULTS

This investigation examined the exercise training patterns and anthropometric characteristics between Novice and Expert amateur motorcycle road racers. More specifically, body mass index (BMI), weight, estimated cardiorespiratory fitness, physical activity, aerobic exercise training patterns and upper and lower body resistance training patterns were compared between novice and expert amateur motorcycle road racers. Novice amateur racers were defined as racers who have attended a motorcycle racing school and received a racing competition license. Expert amateur racers were defined as racers who finished in the top three in any of their Sportsman classes at the Grand National Finals and/or in the top five in points in any class in any region as a "novice" rider.

4.1 BMI, FITNESS, AND PHYSICAL ACTIVITY

An independent sample t-test was performed on BMI between the 2 motorcycle racing classes (novice and expert). The assumption of homogeneity of variance was met, Brown-Forsythe F (1, 51) = .064, p = .801. The assumption of normality was also met for both classes of motorcycle racing (Table 4). All other assumptions were met.

Expert motorcycle racers had significantly lower BMI compared to novice motorcycle racers, t (51) = 2.150, p < .05 (Table 5).

Table 4 Test of Normality of Body Mass Index for Novice and Expert motorcycle racing class

Racing Class	Shapiro-Wilk	df	P= value
Novice	.947	32	.119
Expert	.959	21	.496

Table 5 Body Mass Index (kg/m^2) between motorcycle racing class

Racing Class	N	Mean	SD	P= value
Novice	32	25.77	3.26	.036
Expert	21	23.88	2.93	

A Mann-Whitney U test was performed to compare weight (lbs) between novice and expert motorcycle racing classes. There was no significant difference in weight between novice and expert motorcycle racing classes, $Z = -1.35$ $p = .178$ (Table 6).

Table 6 The mean (lbs), mean rank and sum of ranks of Weight among motorcycle racing classes and P=value for comparison

Racing Class	N	Mean	SD	Mean Rank	Sum of Ranks	P= value
Novice	32	180	30.73	29.31	938.00	.178
Expert	21	166	21.53	23.48	493.00	

An independent sample t-test was performed on estimated cardiorespiratory fitness, represented as estimated maximal metabolic equivalents (MET), in novice and expert motorcycle racing classes. The assumption of homogeneity of variance was met, Brown-Forsythe F (1, 51) = .215, p = .645. The assumption of normality was also met for both classes of motorcycle racing (Table 7). All other assumptions were met.

There was not a significant difference in cardiorespiratory fitness between novice and expert motorcycle racing classes, t (51) = -1.144, p > .05 (Table 8).

Table 7 Test of Normality of Estimated Cardiorespiratory Fitness, represented as estimated maximal metabolic equivalents (MET), for Novice and Expert motorcycle racing class

Racing Class	Shapiro-Wilk	df	P= value
Novice	.986	32	.940
Expert	.975	21	.842

Table 8 Estimated Cardiorespiratory Fitness, represented as estimated maximal metabolic equivalents (MET), between motorcycle racing classes

Racing Class	N	Mean	SD	P= value
Novice	32	12.67	2.10	.258
Expert	21	13.33	1.86	

A Mann-Whitney U test was performed to compare Total physical activity (minutes/week) between novice and expert motorcycle racing classes. There was a significant difference in physical activity between novice and expert motorcycle racing classes, Z = -1.974, p = .048. Expert motorcycle racers had significantly higher Total Physical Activity compared to novice motorcycle racers, p < .05 (Table 9).

Table 9 The mean (min/wk), mean rank and sum of ranks of Total physical activity among motorcycle racing classes and P-value for comparison

Racing Class	N	Mean	SD	Mean Rank	Sum of Ranks	P= value
Novice	32	743	948	23.61	755.50	.048
Expert	21	1110	974	32.17	675.50	

A Mann-Whitney U test was performed to compare Recreational physical activity (minutes/week) between novice and expert motorcycle racing classes. Recreational physical activity was one of the 3 domains assessed in the GPAQ. The recreational domain assessed physical activity in sports, fitness and recreation. There was not a significant difference in Recreational physical activity between novice and expert motorcycle racing classes, $Z = -.538$, $p = .591$ (Table 10).

Table 10 The mean (min/wk), mean rank and sum of ranks of Recreational physical activity among motorcycle racing classes and P-value for comparison

Racing Class	N	Mean	SD	Mean Rank	Sum of Ranks	P= value
Novice	32	335.9	354.6	26.08	834.50	.591
Expert	21	360.0	369.6	28.40	596	

Independent sample t-tests were performed on weight, BMI, estimated cardiorespiratory fitness between novices who participate and do not participate in resistance exercise. No significant differences were found. Novices who participate in resistance exercise had a BMI of 26.39 kg/m^2, a MET score of 13.20 and a mean weight of 184 lbs. Novices who do not participate in resistance exercise had a BMI of 24.98 kg/m^2, a MET score of 24.24 and a mean weight of 174 lbs.

Independent sample t-tests were performed on weight, BMI and estimated cardiorespiratory fitness between experts who participate and do not participate in resistance exercise. A significant difference was found estimated cardiorespiratory fitness ($p = .039$). Expert racers who participate in resistance exercise had a higher MET score compared to expert racers who do no participate in resistance exercise (13.85 compared to 12.03). Experts who participate in resistance exercise had a BMI of 23.73 kg/m^2, a MET score of 13.85 and a mean weight of 164.13 lbs. Experts who do not participate in resistance exercise had a BMI of 24.24 kg/m^2, a MET score of 12.03 and a mean weight of 172 lbs.

Independent sample t-tests were performed on weight, BMI and estimated cardiorespiratory fitness between novices who participate and do not participate in aerobic exercise. No significant differences were found. Novices who participate in aerobic exercise had a BMI of 25.67 kg/m^2, a MET score of 13.18 and a mean weight of 178 lbs. Novices who do not participate in aerobic exercise had a BMI of 26.15 kg/m^2, a MET score of 10.83 and a mean weight of 185 lbs.

Independent sample t-tests were performed on weight, BMI and estimated cardiorespiratory fitness between experts who participate and do not participate in aerobic exercise. No significant difference was found. Experts who participate in aerobic exercise had a BMI of 24.11 kg/m^2, a MET score of 13.62 and a mean weight of 167 lbs. Experts who do not participate in resistance exercise had a BMI of 22.11 kg/m^2, a MET score of 11.56 and a mean weight of 161 lbs.

4.2 AEROBIC EXERCISE PARTICIPATION

A Cross-tabulation for aerobic exercise participation between novice and expert motorcycle racing classes was analyzed. The analysis revealed that 85.7% (18 out of 21) of the expert group and 78.1% (25 out of 32) of the novice group participated in aerobic exercise. A Pearson Chi-Square test revealed that there was no significant difference in aerobic exercise participation between novice and expert motorcycle racing classes (X^2= 1.11; p= .573).

Analysis of the frequency of aerobic exercise (number of days per week) for those who participate in aerobic exercise revealed that 3-4 days/week was selected most by both groups (8 out of 18, 44.4% for Experts and 12 out of 25, 48% for Novices) (table 11). Analysis of the duration of aerobic exercise (number of minutes per session) revealed that 31-45 minutes was the length of time that was selected most by the novice group (10 out of 25, 40%) and 46+ minutes was the length of time selected most by the expert group (10 out of 18, 55.6%) (table 12). A Chi-Square test revealed that there was no significant difference in aerobic exercise frequency and aerobic exercise duration between novice and expert motorcycle racing classes.

Table 11 Aerobic Exercise Frequency (percentages represent within class participants)

Days Per Week	Expert N=21	Novice N=32	X^2	p
0	14.3% (N=3)	21.9% (N=7)	1.61	.657
1 – 2	19.0% (N=4)	25% (N=8)		
3 – 4	38.1% (N=8)	37.5% (N=12)		
5 – 7	28.6% (N=6)	15.6% (N=5)		

Table 12 Aerobic Exercise Duration (percentages represent within class participants)

Minutes per Session	Expert N=21	Novice N=32	X^2	p
0	14.3% (N=3)	21.9% (N=7)	6.03	.110
1 – 15	0% (N=0)	0% (N=0)		
16 – 30	9.5% (N=2)	28.1% (N=9)		
31 – 45	28.6% (N=6)	31.3% (N=10)		
46+	47.6% (N=10)	18.8% (N=6)		

4.3 RESISTANCE EXERCISE PARTICIPATION

A Cross-tabulation for resistance exercise participation between novice and expert motorcycle racing classes was analyzed. The analysis revealed that 71.4% (15 out of 21) of the expert group and 56.3% (18 out of 32) of the novice group participated in resistance exercise. A Pearson Chi-

Square test revealed that there was no significant difference in resistance exercise participation between novice and expert motorcycle racing classes (X^2= 1.46; p= .483).

Analysis of the frequency of resistance exercise (number of days per week) for those who participate in resistance exercise revealed that 3-4 days/week was selected most by both groups (7 out of 15, 46.7% for Experts and 12 out of 18, 66.7% for Novices) (table 13). A Chi-Square test revealed that there was no significant difference in resistance exercise frequency between novice and expert motorcycle racing classes.

Table 13 Resistance Training Frequency (percentages represent within class participants)

Days Per Week	Expert N=21	Novice N=32	X^2	p
0	28.6% (N=6)	43.8% (N=7)	2.75	.432
1 – 2	28.6% (N=6)	12.5% (N=8)		
3 – 4	33.3% (N=7)	37.5% (N=12)		
5 – 7	9.5% (N=2)	6.3% (N=5)		

To investigate upper and lower body resistance training patterns between novice and expert motorcycle racers, muscle groups exercised (shoulders, chest, arms, upper back, lower back, abdominal, legs and calves), specific exercises, and the number of repetitions and sets utilized for each exercise were examined. Examination of the shoulder muscle group revealed that the shoulder press with dumbbells was most widely used for both the expert and novice group, (table 14). Fifty-five percent of experts and 100% of novices used 7-12 repetitions in performing the shoulder press with dumbbells (figure 3). One hundred percent of experts and novices used 1-3 sets in performing the shoulder press with dumbbells (figure 4). A Chi-Square test was utilized to ascertain if there was a significant difference in any particular shoulder exercise. No significant difference was found between novice and expert motorcycle racing classes (table 14).

Table 14 Shoulder muscle group exercise participation (percentages represent within class participants)

Exercise	Expert N=21	Novice N=32	X^2	p
Dumbbell Shoulder Press	42.9% (N=9)	43.8% (N=14)	.004	.949
Barbell Shoulder Press	23.8% (N=5)	21.9% (N=7)	.027	.869
Lateral Dumbbell Raises	23.8% (N=5)	31.3% (N=10)	2.34	.311
Bent-Over Dumbbell Flys	4.8% (N=1)	15.6% (N=5)	1.49	.222
Upright Rows	23.8% (N=5)	34.4% (N=11)	.672	.412

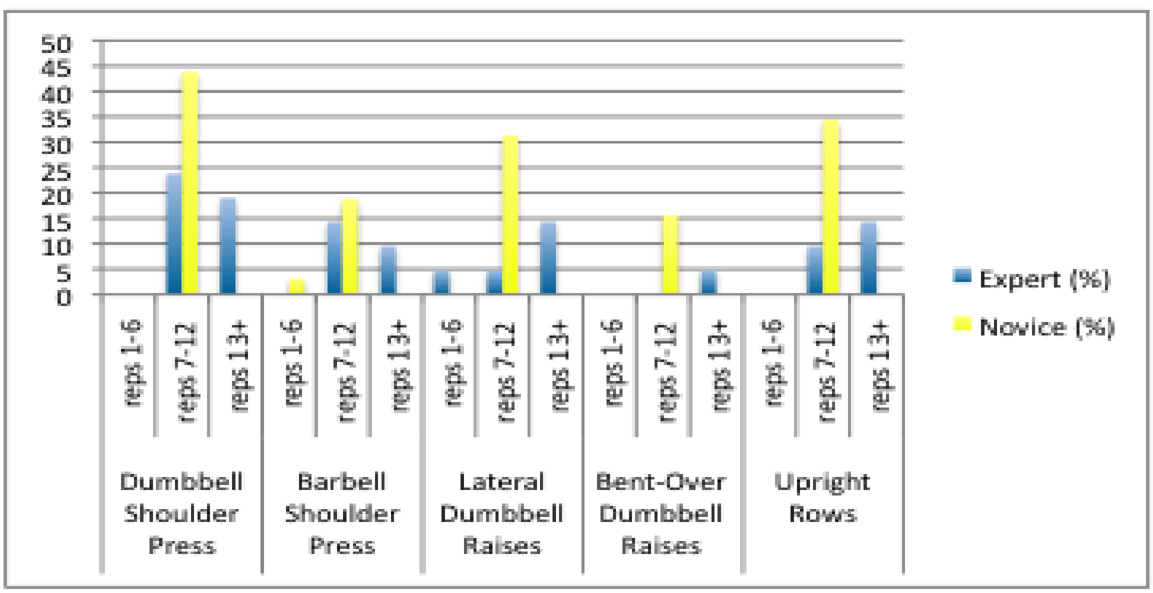

Figure 3 Repetitions of shoulder muscle group exercises

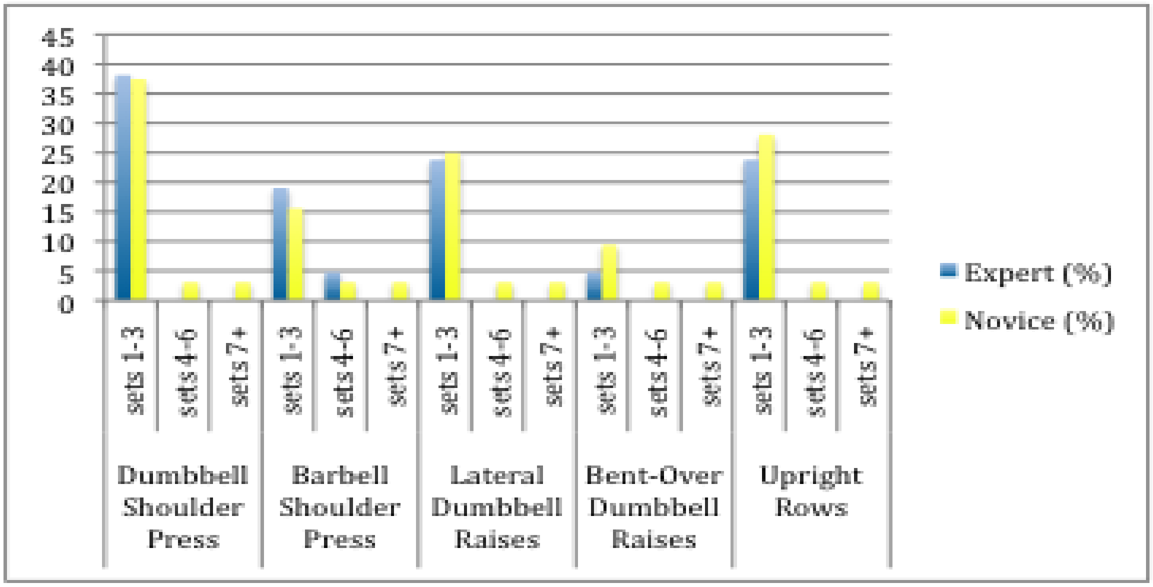

Figure 4 Sets of shoulder muscle group exercises

Examination of exercises focusing on muscles of the chest revealed that the barbell bench press was most widely utilized by both the expert and novice group. Dumbbell flys were also utilized by the same number of participants in the novice group (table 15). Sixty seven percent of experts and 72.2% novices used 7-12 repetitions in performing the barbell bench press. In performing dumbbell flys, 100% of the novice group used 7-12 repetitions (figure 5). Four to six sets were used by 83.3% of the expert group and 1-3 sets were used by 63.6% of the novice group in performing the barbell bench press. One to three sets were used by 81.8% of the novice group in performing dumbbell flys (figure 6). A Chi-Square test was utilized to ascertain if there was a significant difference in any particular chest exercise. No significant difference was found between novice and expert motorcycle racing classes (table 15).

Table 15 Chest muscle group exercise participation (percentages represent within class participants)

Exercise	Expert N=21	Novice N=32	X^2	p
Dumbbell Bench Press	23.8% (N=5)	31.3% (N=10)	.346	.556
Barbell Bench Press	28.6% (N=6)	34.4% (N=11)	.196	.658
Dumbbell Flys	19.0% (N=4)	34.4% (N=11)	1.47	.226

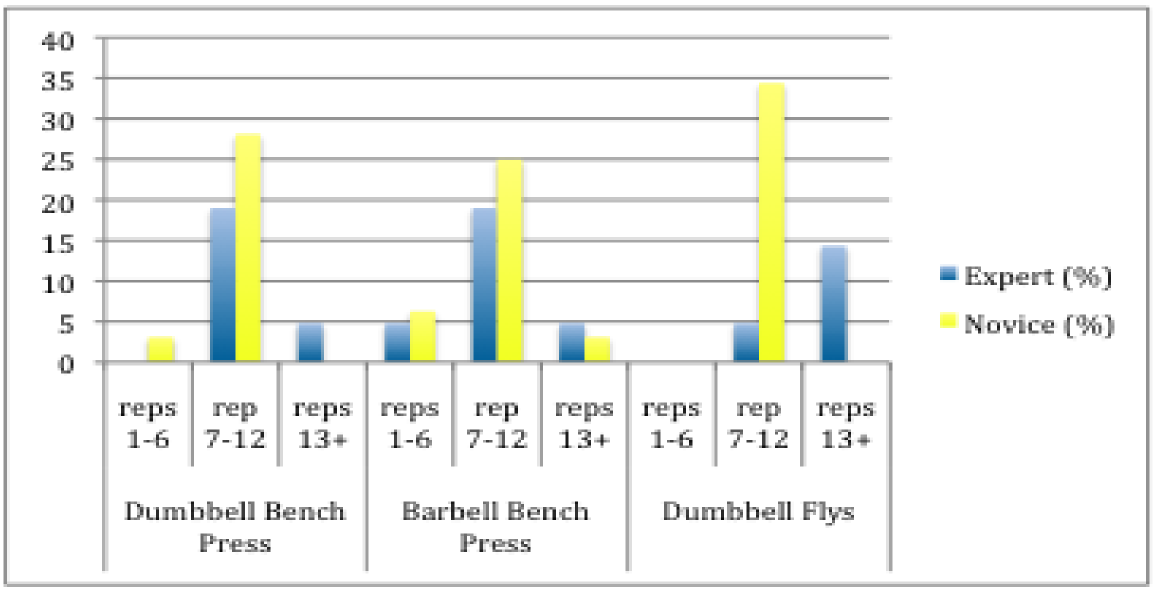

Figure 5 Repetitions of chest muscle group exercises

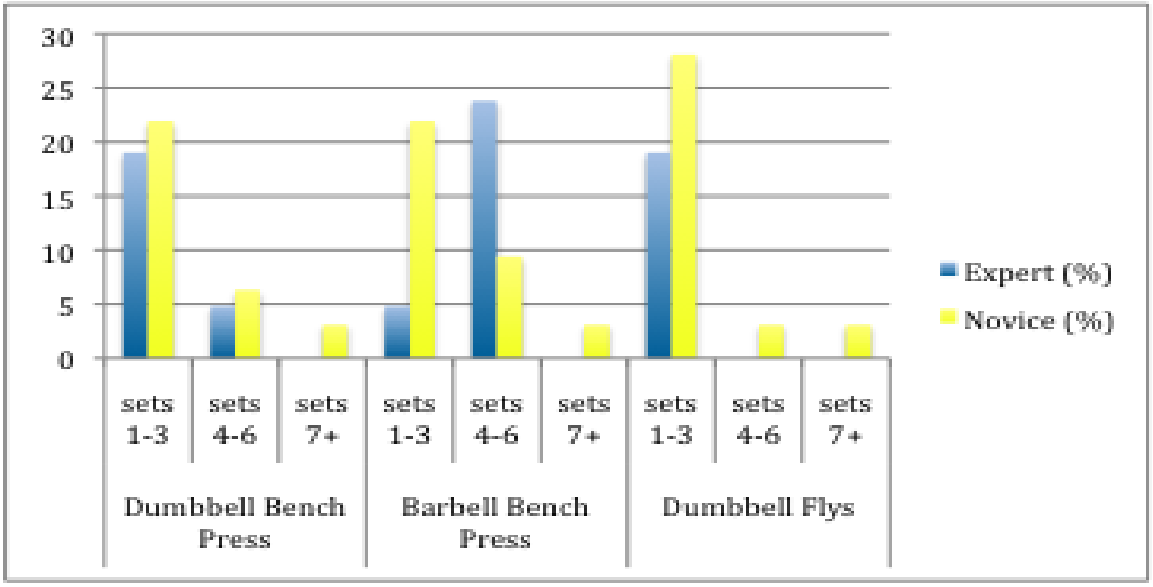

Figure 6 Sets of chest muscle group exercises

Examination of exercises focusing on muscles of the arm showed that dumbbell bicep curls was selected most by both the expert and novice group (table 16). Thirteen or more repetitions were used in performing dumbbell bicep curls by 54.5% of the expert group (figure 7). Seven to twelve repetitions were used in performing dumbbell bicep curls by 84.6% of the novice group. Sixty-three percent of experts and 76.9% of the novices used 1-3 sets in performing dumbbell bicep curls (figure 8). A Chi-Square test was utilized to ascertain if there was a significant difference in any particular arm exercise. No significant difference was found between novice and expert motorcycle racing classes (table 16).

Table 16 Arm muscle group participation (percentages represent within class participants)

Exercise	Expert N=21	Novice N=32	X^2	p
Dumbbell Bicep Curls	52.4% (N=11)	40.6% (N=13)	.707	.400
Barbell Bicep Curls	9.5% (N=2)	28.1% (N=9)	2.67	.102
Wrist Curls	23.8% (N=5)	9.4% (N=3)	2.06	.151
Reverse Wrist Curls	28.6% (N=6)	9.4% (N=3)	3.31	.069
Tricep Push Downs	33.3% (N=7)	34.4% (N=11)	.006	.938
Tricep Extensions	33.3% (N=7)	34.4% (N=11)	.006	.938

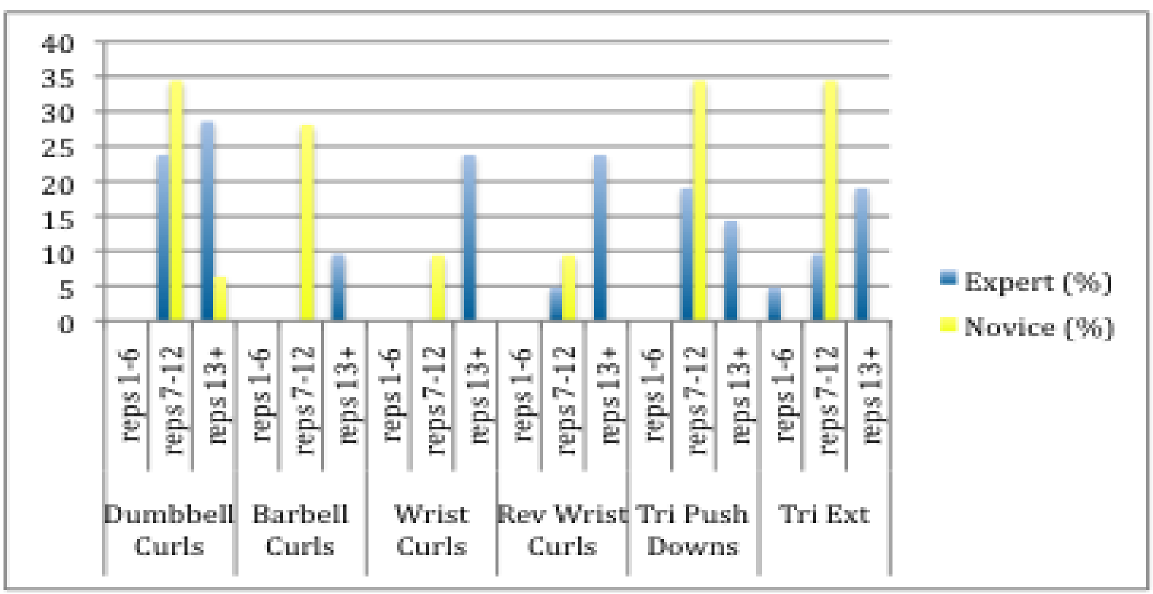

Figure 7 Repetitions of arm muscle group exercises

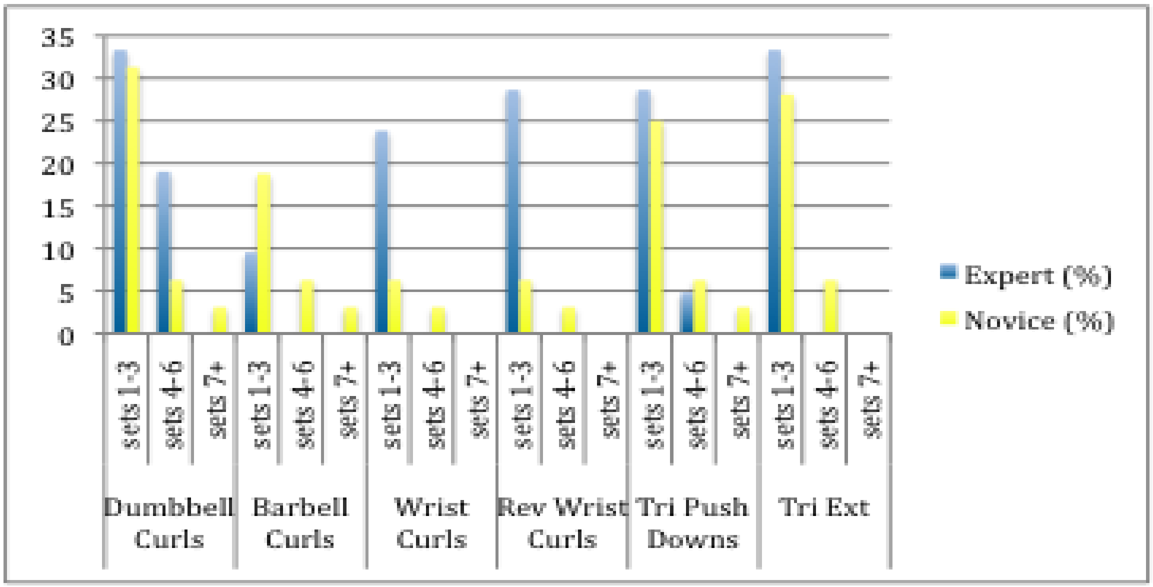

Figure 8 Sets of arm muscle group exercises

Examination of the upper back muscle group showed the latissimus pull down was the exercise selected most by both the expert and novice group (table 17). An equal number of experts (42%) used either 7-12 repetitions or 13 or more repetitions in performing lat pull downs; whereas 90.9% of the novice group used 7-12 repetitions (figure 9). One to three sets were most widely used when performing lat pull downs in both the expert and novice group, 100% and 75% respectively (figure 10). A Chi-Square test was utilized to ascertain if there was a significant difference in any particular upper back exercise. No significant difference was found between novice and expert motorcycle racing classes (table 17).

Table 17 Upper Back muscle group exercise participation (percentages represent within class participants)

Exercise	Expert N=21	Novice N=32	X^2	p
Latissimus Pull Downs	33.3% (N=7)	34.4% (N=11)	.006	.938
Seated Rows	23.8% (N=5)	25.0% (N=8)	.010	.922

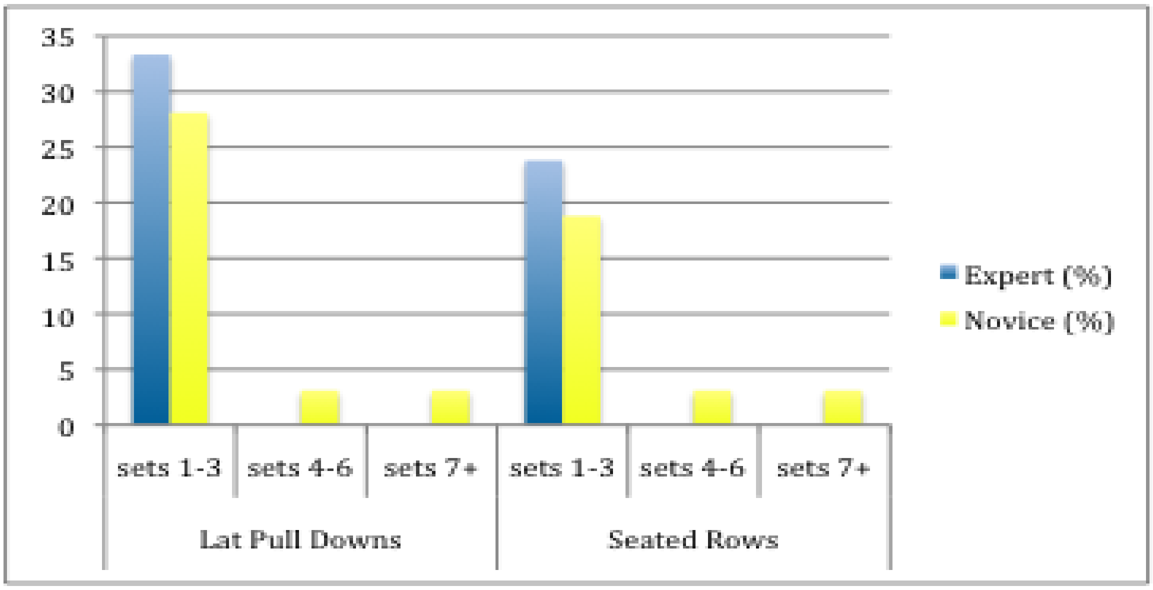

Figure 9 Repetitions of upper back muscle group exercises

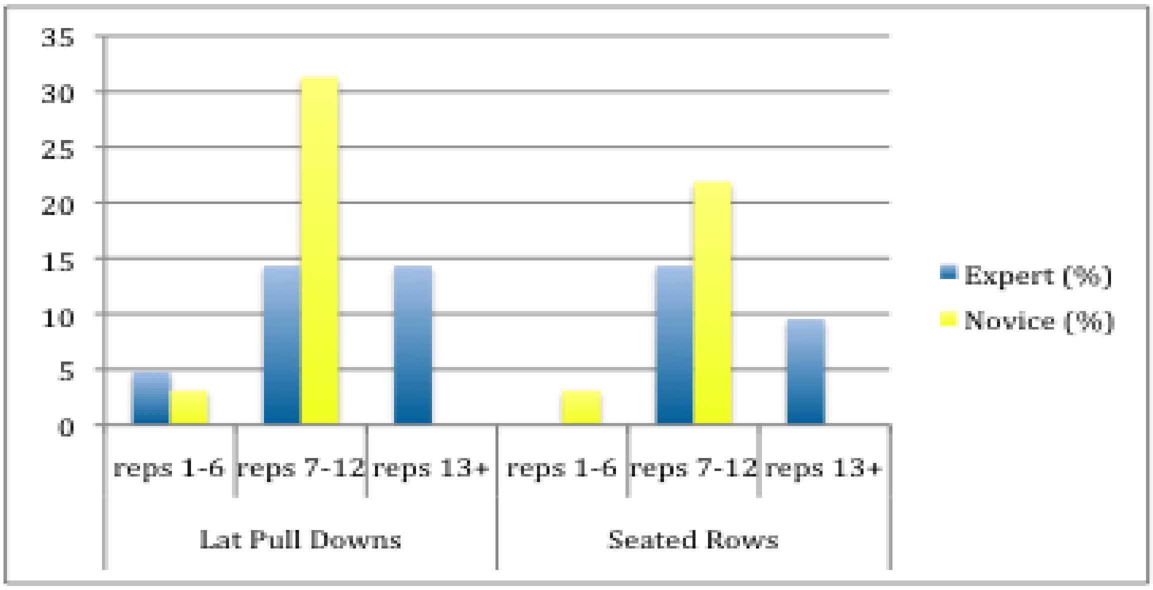

Figure 10 Sets of upper back muscle group exercises

Examination of the lower back muscle group exhibited that the back extension was the exercise selected most by the expert and novice group (table 18). Fifty percent of the expert group and 80% of the novice group utilized 7-12 repetitions when performing back extensions (figure 11). Fifty percent of the expert group utilized 13 or more repetitions when performing back extensions. One hundred percent of the expert group and 60% of the novice group utilized 1-3 sets when performing back extensions (figure 12). A Chi-Square test was utilized to ascertain if there was a significant difference in any particular lower back exercise. No significant difference was found between novice and expert motorcycle racing classes (table 18).

Table 18 Lower Back muscle group exercise participation (percentages represent within class participants)

Exercise	Expert N=21	Novice N=32	X^2	p
Deadlifts	4.8% (N=1)	12.5% (N=4)	.889	.346
Back Extensions	19.0% (N=4)	15.6% (N=5)	.105	.745

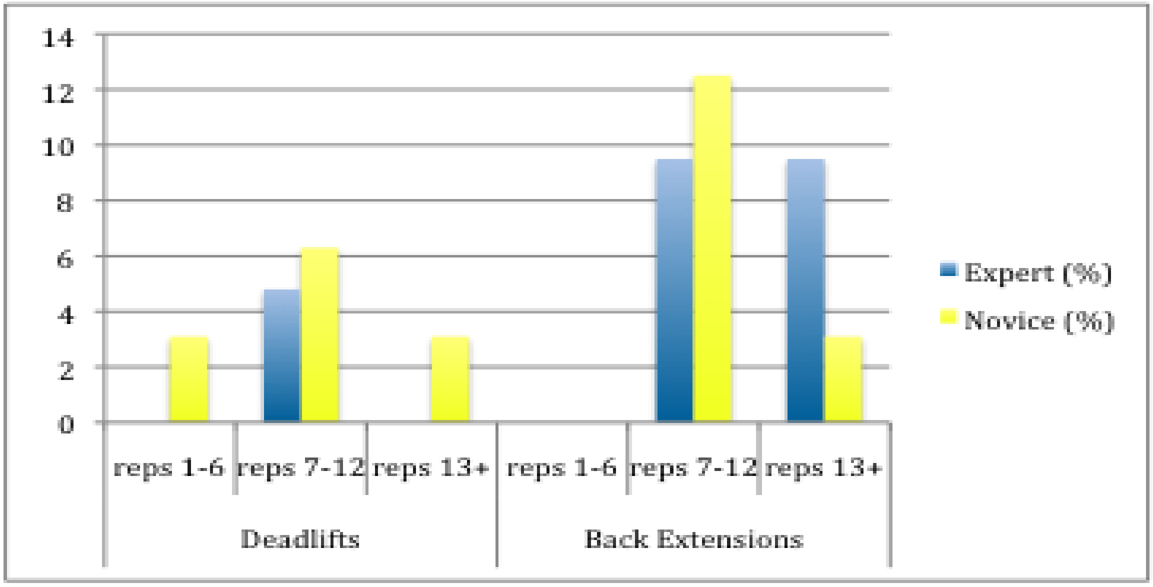

Figure 11 Repetitions of lower back muscle group exercises

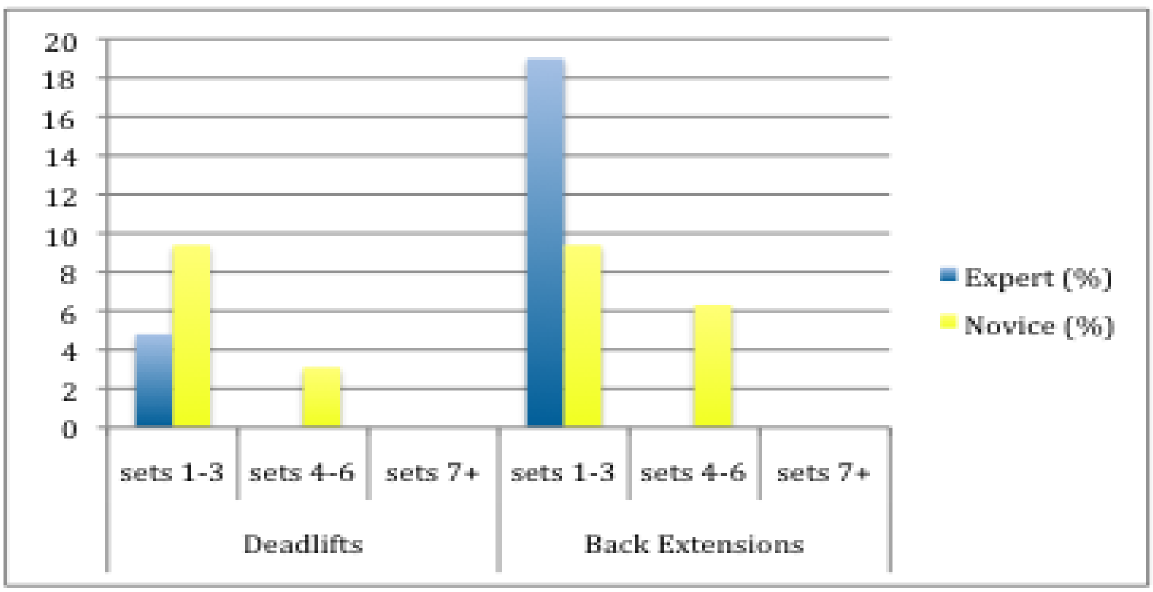

Figure 12 Sets of lower back muscle group exercises

Examination of exercises for the abdominal muscle group showed that the crunch was the most widely used exercise by both the expert and novice groups (table 19). Twenty-six or more repetitions were utilized by 36.4% of the expert group and 42.9% of the novice group in performing crunches. The same percentage of the expert group (36.4) performed 16-25 repetitions in performing crunches (figure 13). Eighty two percent of the expert group and 85.7% of the novice group utilized 1-3 sets in performing crunches (figure 14). A Chi-Square test was utilized to ascertain if there was a significant difference in any particular abdominal exercise. No significant difference was found between novice and expert motorcycle racing classes (table 19).

Table 19 Abdominal muscle group exercise participation (percentages represent within class participation)

Exercise	Expert N=21	Novice N=32	X^2	p
Crunches	52.4% (N=11)	43.8% (N=14)	.379	.538
Sit-ups	23.8% (N=5)	34.4% (N=11)	.672	.412
Leg Raises	28.6% (N=6)	25.0% (N=8)	.083	.773

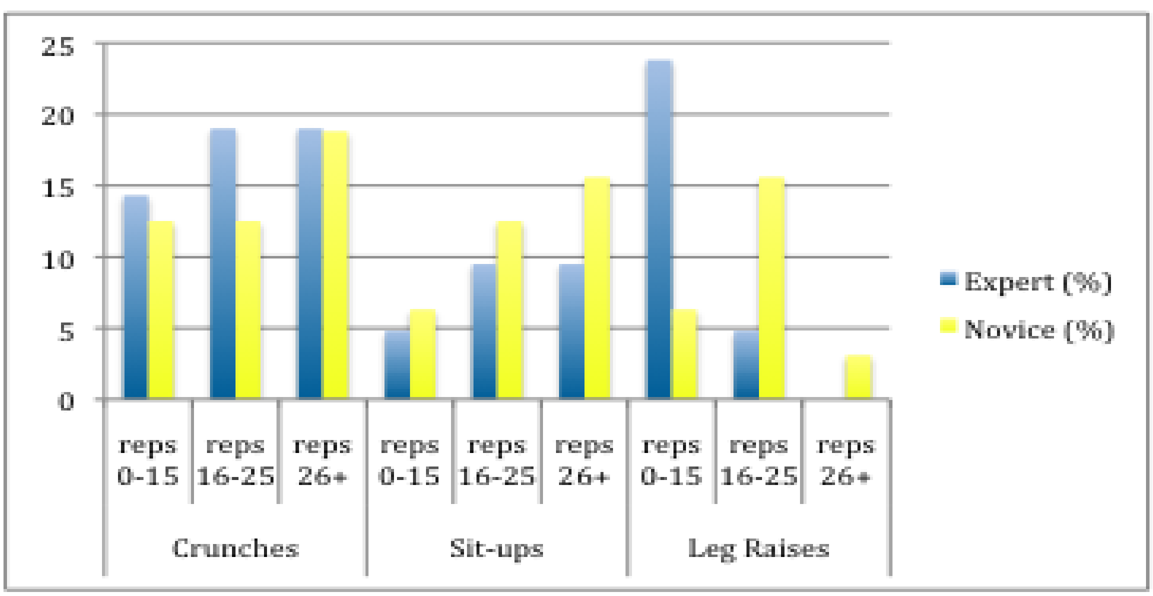

Figure 13 Repetitions of abdominal muscle group exercises

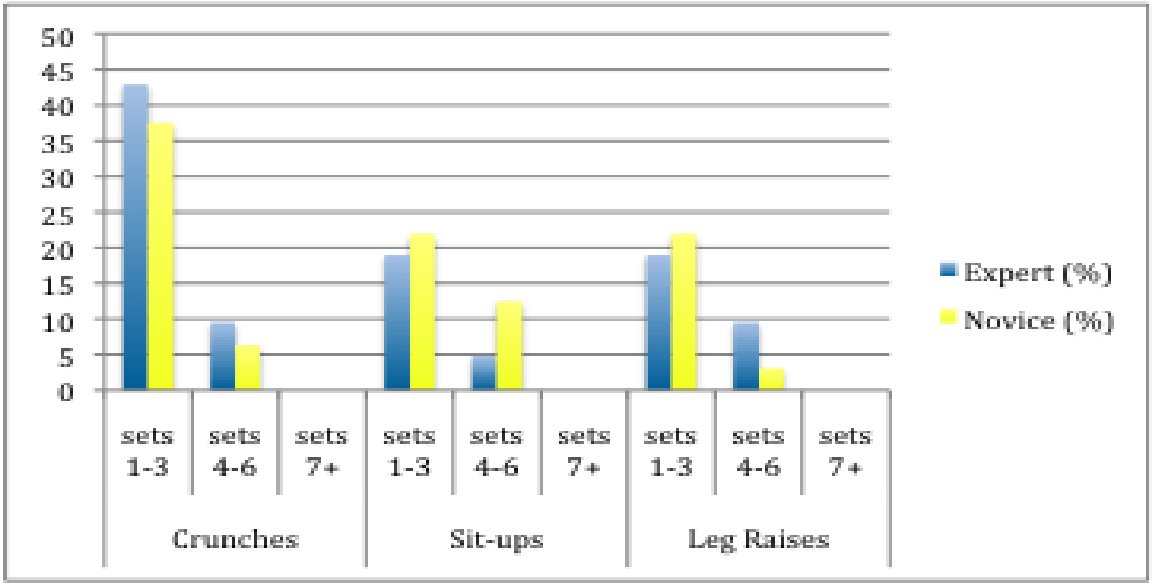

Figure 14 Sets of abdominal muscle group exercises

Examination of exercises focusing on muscles of the legs revealed that the leg press was the exercise selected most by the expert group and the lunge was the exercise selected most by the novice group (table 20). Sixty six percent of the expert group used 7-12 repetitions when performing the leg press. Seventy two percent of the novice group used 7-12 repetitions when performing lunges (figure 15). One to three sets were used by 83.3% of experts in performing leg presses and 72.7% of novices in performing lunges (figure 16). A Chi-Square test was utilized to ascertain if there was a significant difference in any particular leg exercise. A significant difference was found in lunges, p= .040, between novice and expert motorcycle racing classes (table 20).

Table 20 Leg muscle group exercise participation (percentages represent within class participants)

Exercise	Expert N=21	Novice N=32	X^2	p
Dumbbell Squats	4.8% (N=1)	15.6% (N=5)	1.49	.222
Barbell Squats	19.0% (N=4)	21.9% (N=7)	.062	.804
Lunges	9.5% (N=2)	34.4% (N=11)	4.23	.040
Leg Press	28.6% (N=6)	18.8% (N=6)	.698	.403
Leg Curls	9.5% (N=2)	15.6% (N=5)	2.90	.235

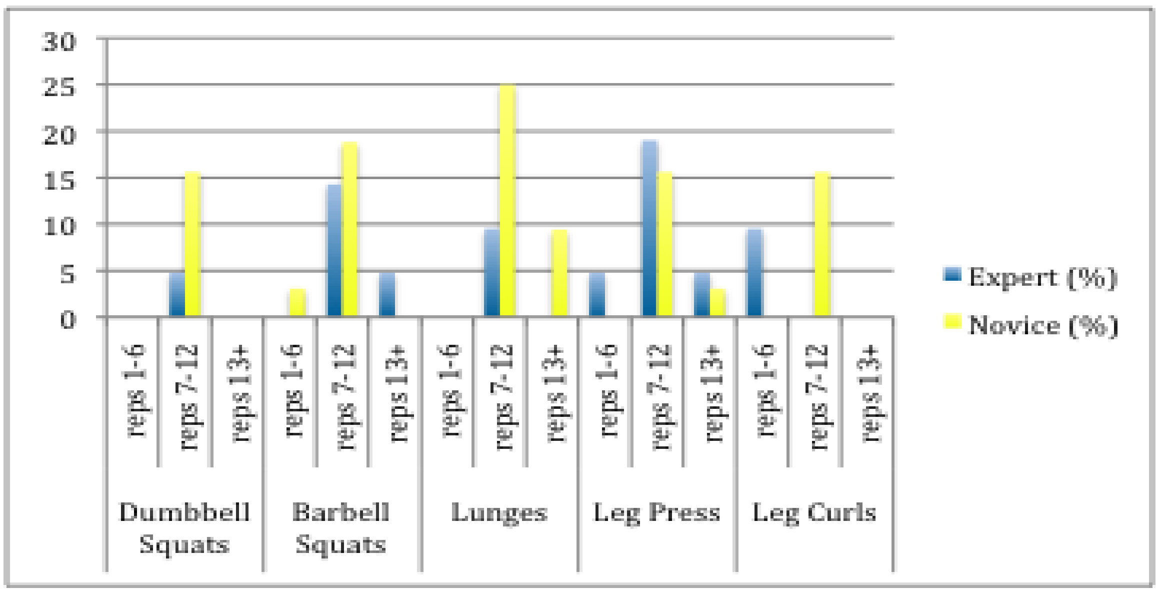

Figure 15 Repetitions of leg muscle group exercises

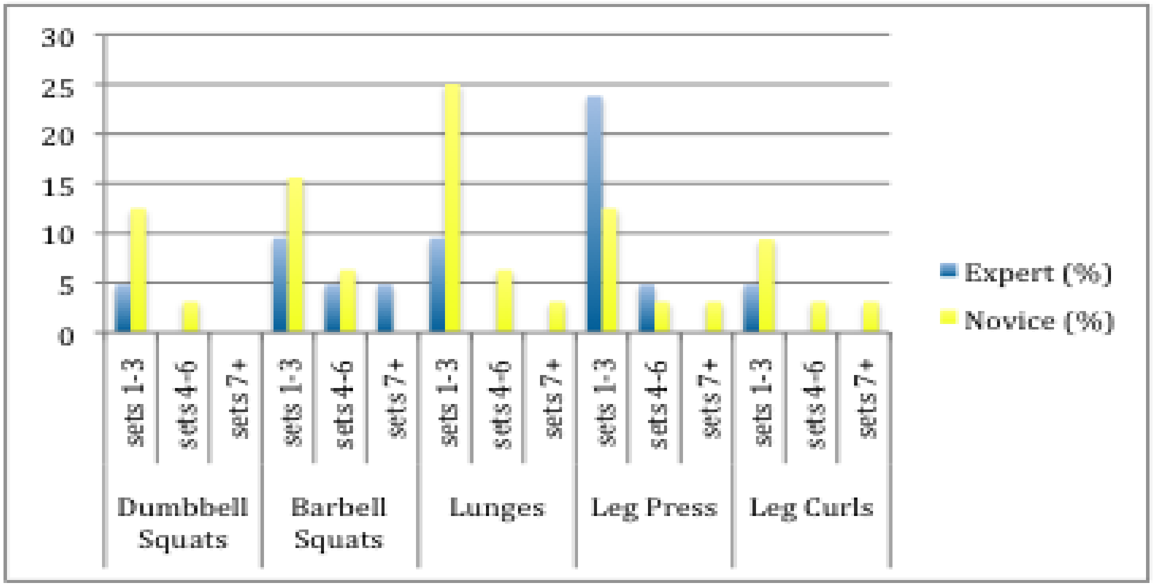

Figure 16 Sets of leg muscle group exercises

Examination of exercises that focus on the calf muscle group revealed that 26.6% of the expert group performed standing calf raises and 26.6% performed seated calf raises; whereas the 55.5% of the novice group employed standing calf raises (table 21). In the performance of standing calf raises 75% of the expert group and 50% of the novice group utilized 13 or more repetitions in performing standing calf raises. Fifty percent of the novice group used 7-12 repetitions in performing standing calf raises. When performing seated calf raises, 75% of the expert group utilized 13 or more repetitions (figure 17). When performing standing calf raises, 75% of the expert group and 60% of the novice group used 1-3 sets. When performing seated calf raises, 100% of the expert group used 1-3 sets (figure 18). A Chi-Square test was utilized to ascertain if there was a significant difference in any particular calf exercise. No significant difference was found between novice and expert motorcycle racing classes (table 21).

Table 21 Calf muscle group exercise participation (percentages represent within class participants)

Exercise	Expert N=21	Novice N=32	X^2	p
Standing Calf Raises	19.0% (N=4)	31.3% (N=10)	.971	.324
Seated Calf Raises	19.0% (N=4)	9.4% (N=3)	1.04	.309
Donkey Calf Raises	0% (N=0)	6.3% (N=2)	1.36	.243

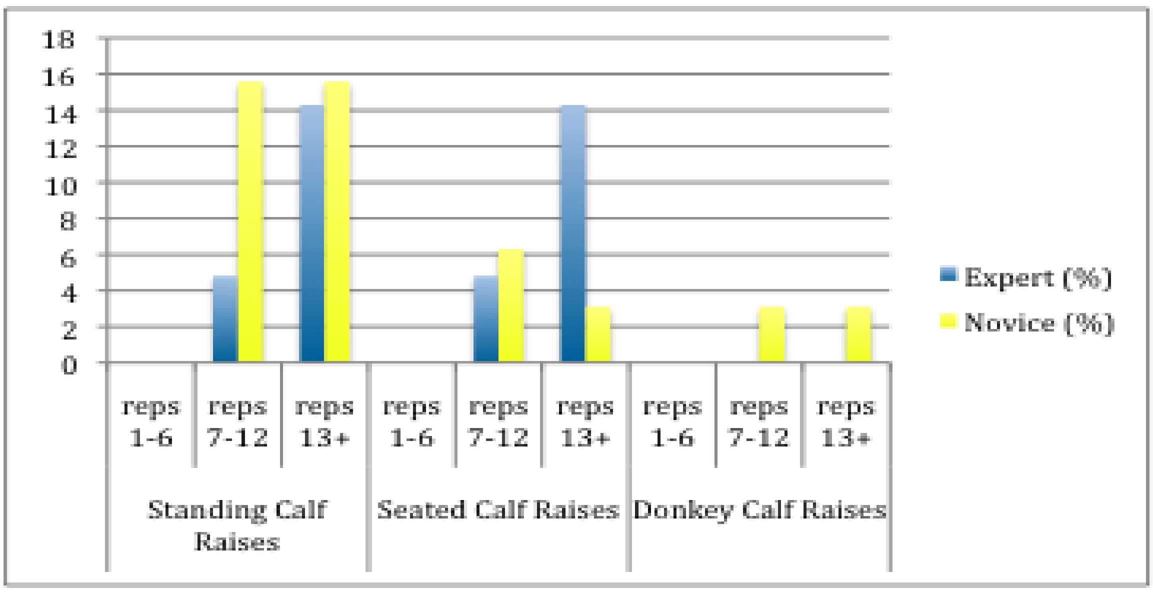

Figure 17 Repetitions of calf muscle group exercises

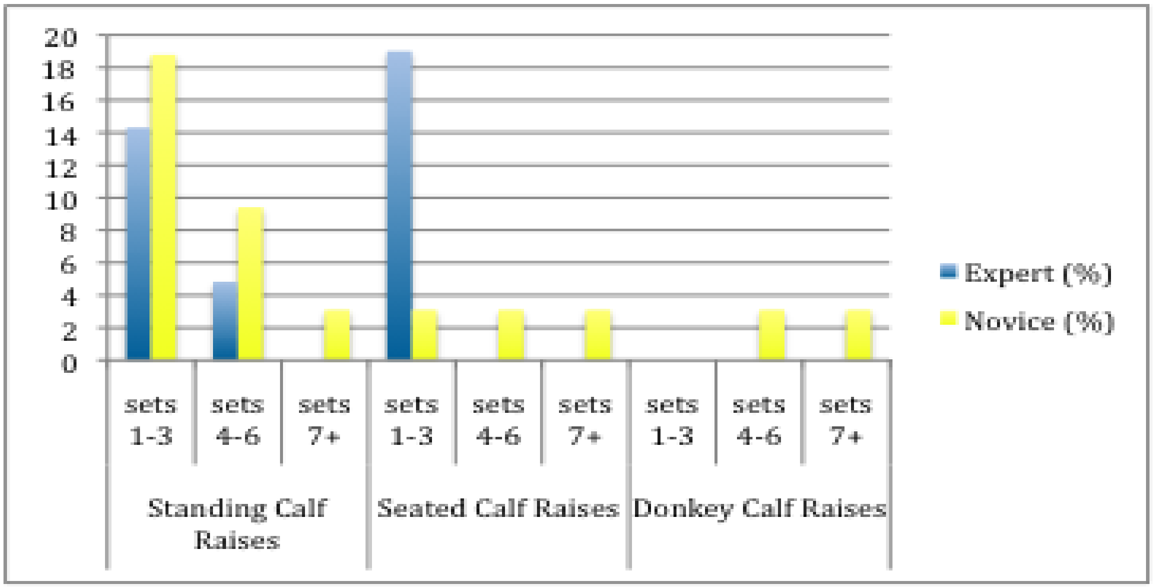

Figure 18 Sets of calf muscle group exercises

4.4 SUMMARY

There were no significant differences between expert and novice amatuer motorcycle road racers in weight, estimated cardiorespiratory fitness and recreational physical activity (min/week), p= .178, p= .258 and p= .591, respectively. However, statistical analysis did reveal that expert's mean BMI of 23.55 kg/m^2 was significantly less than novice's mean BMI of 25.77 kg/m^2 (p=.036) Also, statistical analysis reveal that expert's mean total physical activtiy of 1110 min/week was significantly higher than novice's mean total physical acitvity of 743 min/week (p=.048).

The investigation examined participation in aerobic exercise and resistance exercise among expert and novice racers. Chi-square tests revealed that there were no significant differences in aerobic exercise participation and resistance exercise participation between expert and novice amateur motorcycle road racers, p= .573 and p= .483 respectively. The study examined the frequency and duration of aerobic exercise in expert and novice racers. A Chi-square test revealed no significant difference between expert and novice racers in frequency and duration of aerobic exercise, p= .675 and p= .110 respecitively. A Chi-square test for resistance exercise frequency revealed no significant difference (p= .432) between motorcycle racing groups.

This study further analyzed data concerning differences in upper and lower body resistance exercises between expert and novice racers. Chi-square tests on the collected data revealed a significant difference in leg lunges, p= .040. The novice group had a higher percentage of participation for leg lunges compared to the expert group. No other significant differences were discovered between expert and novice amatuer motorcycle road racers in resistance exercises.

5.0 DISCUSSION

There is evidence that exercise is an important component in preparing for competition. Failure to properly train for a competitive sport can lead to performance decrements, fatigue and injury (Davey et al., 2002; Stone, 1990; Hewett et al., 1999). Through the implementation of appropriate exercise training programs, athletes can improve body composition, muscular strength and endurance, ligament and bone integrity for injury prevention, the efficiency of the metabolic energy systems, cardiorespiratory fitness, and other physiological parameters that may be important for athletic performance (Kraemer et al., 1996; Deschenes & Kraemer, 2002). However, exercise programs may need to be tailored to the specific needs of the individual athlete and the physiological and biochemical demands of a particular sport to significantly improve athletic performance.

The scientific literature has shown the importance of sport-specific characteristics that may be linked to improved performance in a variety of sports and athletic events (Terbizan et al., 1996; Lephart et al., 2005; Szymanski et al., 2007; Lachowetz et al., 1998; Girold et al., 2006; Mihalik et al., 2008). Based on these findings, sport-specific exercise training programs have been developed to enhance athletic performance (Murlasits & Langley, 2002; Barrett et al., 2007; Everline, 2007).

While there is available research on sport specific training for a variety of sports, there are limited data available on motorcycle road racers. The review of the available scientific literature revealed that the only studies conducted on motorcycle road racers have been limited to identification of the types of physical injuries sustained by athletes participating in this sport (Tomida et al., 2005). Furthermore, no scientific literature was identified that characterized the physiological parameters associated with improved performance in this sport.

Investigations examining motorcycle riders have been limited to off-road motorcycling. Gobbi et al. (2005) reported that off-road motorcycling requires the active involvement of the entire musculoskeletal system with aerobic metabolism maintained at a level slightly above the anaerobic threshold. Other investigations have similarly demonstrated the physical demands of off-road motorcycle riding (Konttinen et al., 2008; Burr et al. 2010; Ascensao et al., 2008; Collins et al., 1993). Despite theses investigations of off-road motorcycling, there still exists a dearth of information concerning the physiological and anthropometric characteristics of motorcycle road racing. Albeit motocross and motorcycle road racing are different motorcycle riding endeavors, the sport provides the greatest similarity for comparison. The information provided by the investigations of off-road motorcycling suggests that weight, BMI, aerobic capacity and muscular strength and endurance appear to be components of motorcycle riding performance. Therefore, this investigation focused on examining the exercise training patterns and anthropometric characteristics between Novice and Expert amateur motorcycle road racers. More specifically, the current study was designed to conduct an initial study of body mass index, cardiorespiratory fitness, aerobic exercise participation, frequency and duration, and upper and lower body resistance exercise participation, frequency, selection, repetitions and sets.

5.1 BMI, CARDIORESPIRATORY FITNESS AND PHYSICAL ACTIVITY

A primary aim of this study was to examine the body mass indicies of Novice and Expert amateur motorcycle road racers. Expert racers had a significantly lower ($p \leq .05$) body mass index compared to novice racers. The mean BMI for experts was 23.88 kg/m^2 whereas the mean BMI for novice racers was 25.77 kg/m^2. By clinical standards, the novice racers were overweight whereas the expert racers were normal.

The findings in this study are similar to what has been reported in other motor sports. Konttinen et al. (2008) found that Finnish A-level (competitive) and hobby motocross riders had body mass indicies of 22.0 kg/m^2 and 24.0 kg/m^2, respectively. The investigators did not assess whether there was a significant difference between the two classes of riders but one can observe that the competitive group had a lower body mass index. Burr et al. (2010) reported that habitual recreational off-road motorcyclists had body mass indicies ranging from to 24.5 kg/m^2 to 27.2 kg/m^2. In another investigation, Gobbi et al. (2005) found top-level international motocross racers to have body mass indicies of 23.7 kg/m^2.

It has been suggested that being overweight in motorsports is unfavorable because it overloads the bike as well as provides extra mass that must be accelerated (and decelerated during braking). Therefore, the heavier rider requires more muscular force for optimal control of the motorcycle (Gobbi et al. 2005). Albeit expert racers had a significantly less BMI compared to novice racers, correlating the lesser BMI to their racing classification should be done with caution. It is known that the BMI equation may be inaccurate for athletes with greater muscle mass opposed to fat. Without having measurements of body fat percentage, one must consider the possibility of inaccuracy when comparing expert and novice motorcycle road racer body mass indexes. Therefore an analysis of mass was performed between the two classes. No significant difference was found. Novice racers had a mean weight of 180.13 lbs and experts had a mean weight of 166.43 lbs. If the current study had a larger sample size, the difference might have reached statistical significance. Nonetheless, the importance of body mass should not be overlooked. The current study revealed a significant difference between the racing classes in BMI but body weight may be the more important component in racing performance. For instance, BMI incorporates height into the equation but it is weight that may be a factor in the effects of acceleration out of corners and deceleration when braking. It is merely the equation of force = mass x acceleration when considering the importance of body weight (i.e. mass) on motorcycle racing performance.

Another primary aim of the current study was to examine cardiorespiratory fitness of Novice and Expert amateur motorcycle road racers. The current investigation established no significant difference ($p > .05$) in estimated cardiorespiratory fitness between Expert and Novice motorcycle road racers, resulting in a rejection of the hypothesis. Expert racers had a mean MET score of 13.33 and novice racers had a mean MET score of 12.66. When METs are converted to VO_2 (13.33 METs x 3.5 ml/kg/min = 46.65; 12.66 METs x 3.5 ml/kg/min = 44.31), results in this study are similar to other investigations that examined VO_{2max} of motocross racers. Albeit motocross and motorcycle road racing are different motorcycle riding endeavors, the sport provides the greatest similarity to compare data.

Konttinen et al. (2008) examined maximal aerobic capacity of motocross riders on a cycle ergometer. The investigators reported that competitive motocross riders and hobby motocross riders had maximal aerobic capacities of 49 ml/kg/min and 43 ml/kg/min, respectively. These findings are similar to the results of the current study where expert and novice racers had estimated aerobic capacities of 46.65 ml/kg/min and 44.31 ml/kg/min, respectively. Burr et al. (2010) reported habitual recreational off-road motorcyclist to have maximal aerobic capacities ranging from 51.8 ml/kg/min to 43.4 ml/kg/min. Ascensao et al. (2008) reported maximal aerobic capacities of 53.3 ml/kg/min in competitive motocross racers. However, Gobbi et al. (2005) reported top-level motocross racers to have maximal aerobic capacities of 57.5 ml/kg/min. The high maximal aerobic capacities reported by Gobbi et al. (2005) may be a reflection of the racing level of riders that were examined; the riders were top-level with international racing experience. Although motocross and motorcycle road racing are different motorcycle riding sports, the reports of top-level international riders by Gobbi et al. (2005) may suggest that higher aerobic capacities can be beneficial to the Expert and Novice amateur motorcycle road racers of the current study.

Other investigations have examined aerobic capacities in different sports. Reports of maximal aerobic capacities range from 52.5 ml/kg/min to 43.5 ml/kg/min in American football players (Pincivero & Bompa, 1997), 62.4 ml/kg/min to 48.1 ml/kg/min in young non-elite soccer players (Gil et al. 2007), 59.7 ml/kg/min to 54.6 ml/kg/min in elite Serbian basketball players (Ostojic et al., 2006) and 53.1 ml/kg/min to 52.2 ml/kg/min in National Hockey League players (Agre et al., 1988). The maximal aerobic capacities of athletes in these sports may reflect the demands of the particular sport and the positions within that particular sport. The estimated aerobic capacities of expert and novice amateur motorcycle road racers in the current study may indicate the physical demand of this unique motor sport. However, it should be noted that to accurately assess the aerobic capacity associated with enhanced motorcycle road racing performance, the estimated aerobic capacities of this study’s participants should be compared to elite motorcycle road racers.

Another primary aim of this study was to examine total physical activity in amateur motorcycle road racers. Results from this study demonstrated a significantly higher total physical activity in expert racers compared to novice racers, thus accepting the hypothesis. Expert racers participated in 1110 min/week of total physical activity, whereas novice racers participated in 743 min/week of total physical activity. It was hypothesized that expert racers would have greater physical activity but we cannot conclude with specificity what type of physical activity would contribute to improved racing classification.

An additional statistical analysis was performed on the Recreational physical activity domain of the survey. No significant difference ($p > .05$) was found in recreational physical activity between expert and novice amateur motorcycle road racers. The recreational domain assessed minutes of participation in any sports, fitness or recreational activity. Expert racers participated in 360 min/week of recreational activities whereas novice racers participated in 335 min/week.

Although there was not a significant difference between expert and novice racers in recreational activity, both classes of racers participated in nearly 6 hours of recreational activity per week. Research in other sports has demonstrated that physical activity/exercise can improve performance characteristics (Terbizan et al., 1996; Lephart et al., 2005; Szymanski et al., 2007). Girold et al. (2006) investigated competitive-level swimmers that participated in sport-specific and traditional training or traditional training only for 3 weeks. Reports indicated that when compared to traditional training alone, greater physical activity specific to swimming (i.e. sport-specific and traditional combined) contributed to improved swimming-related strength parameters, swimming performance and stroke rate. The sport-specific and traditional training group improved their 100m performance by 2% whereas the traditional training only group exhibited a -0.3% decline over 3 weeks. Lachowetz et al. (1998) investigated college baseball players that participated in either a throwing program combined with strength training or a throwing program only. Reports demonstrated that physical activity/exercise contributed to improved performance characteristics associated with baseball throwing velocity when compared to no or less physical activity. The strength training group improved their throwing velocity up to 5.25mph whereas the throwing velocity of the group that only participated in the throwing program declined. These reports (Girold et al., 2005; Lachowetz et al., 1998) indicate that expert and novice racers of the current study may have benefited from their participation in recreational physical activity. However, we cannot specify what particular fitness paradigms, exercises, repetitions or sets would be beneficial.

5.2 AEROBIC EXERCISE PARTICIPATION

The results of the investigation demonstrated no significant difference in aerobic exercise participation between Expert and Novice amateur motorcycle road racers ($p > .05$). Thus, the hypothesis was rejected. Participation in aerobic exercise in the expert group was 85.7% (18 out of 21) whereas participation in the novice group was 78.1% (25 out of 32). The findings of this study revealed a large percentage of aerobic exercise participation in both classes of racers. Sport conditioning programs of other sports have consistently incorporated aerobic exercise to improve performance (Everline, 2007). Thus, the large percentage of aerobic exercise participation in the current study is consistent with suggested sport conditioning programs in other sports. There was not a significant difference in frequency of aerobic exercise between the expert and novice motorcycle road racers. Table 11 indicates that 3-4 days per week was selected by the greater percentage in both groups. Although there was not a significant difference between expert and novice motorcycle road racers concerning duration of aerobic exercise, the largest percentage of expert racers selected 46+ minutes of aerobic exercise whereas the largest percentage of novice racers selected 31-45 minutes of aerobic exercise.

Research in exercise science demonstrates physiological adaptations specific to the type of training employed (Campos et al. 2002; Kanehisa & Miyashita, 1983; Tabata et al., 1996). If one were to speculate the type of training these individuals (both expert and novice) were employing, it would be non-anaerobic. Training 30 minutes or more of aerobic exercise would be training the aerobic energy system. Therefore, we cannot conclude, based on the data on this investigation, that the expert group trained differently than the novice group as both groups trained longer than 30 minutes. We also cannot conclude from the collected data that training any specific energy system would improve amateur motorcycle road racing classification or performance. However, it has been demonstrated that endurance training can reduce psycho-emotional stress and increase psychological capacity and stress tolerance (Schwaberger, 1987). And it has been suggested that psycho-emotional stress is associated with riding a motorcycle due to the extremely high level of required concentration (Collins et al., 1993).

Furthermore, aerobic exercise has also been shown to improve fatigue resistance (Baechle & Earle, 2000; Powers & Howley, 2004). Fatigue has been shown to reduce motor skill, muscular force production and senorimotor system acuity (Tripp et al., 2007). The sensorimotor system is responsible for providing the awareness, coordination, and feedback to joints for reproducing motions and stability. As races at the elite (Moto Gp) level last up to 45 minutes in length, muscular and central fatigue can induce performance decrements. Therefore, aerobic/endurance training should be considered in the sport conditioning of motorcycle racers.

5.3 RESISTANCE EXERCISE PARTICIPATION

The current study demonstrated no significant difference in resistance exercise participation between expert and novice amateur motorcycle road racers (p> .05). Participation in resistance exercise in the expert group was 71.4% (15 out of 21) whereas participation in the novice group was 56.3% (18 out of 32). These findings reject the hypothesis. However, the findings of this study did reveal that over 50% of both racing classes did participate in resistance exercise. Sport conditioning programs of other sports have consistently incorporated resistance exercise to improve performance and prevent injury (Murlasits & Langley, 2002; Judge, 2007; Marques et al., 2006; Jones & Bampouras, 2007; Barrett et al., 2007). Thus, the large percentage of resistance exercise participation in the current study is consistent with suggested sport conditioning programs in other sports. However, based on the collected data, we cannot conclude that resistance exercise participation is associated with improved motorcycle road racing classification.

Evidence in other investigations has shown that resistance training may improve athletic performance (Kraemer, 1985; Kraemer et al., 1996; Deschenes & Kraemer, 2002). Lephart et al. (2005) developed an eight week golf specific exercise program based on previously identified characteristics involved in improved golf play. The exercise program resulted in improved golf-specific strength, flexibility and balance. Szymanski et al. (2007) reported improvements in bat swing velocity in high school baseball players after 12 weeks of resistance exercise training. Lachowetz et al. (1998) investigated college baseball players that participated in a strength training regimen to improve baseball throwing velocity. Reports demonstrated that resistance exercise contributed to improved performance characteristics associated with baseball throwing velocity. The strength training improved throwing velocity up to 5.25mph. The aforementioned research suggests that resistance exercise participation might improve performance in motorcycle road racers.

Moreover, resistance training has been associated with improved BMI (Powers & Howley, 2004, ACSM, 2002). As previously mentioned, being overweight in motorsports is unfavorable because it overloads the bike as well as provides extra mass that must be accelerated (and decelerated during braking) (Gobbi et al. 2005). It should be encouraged that motorcycle road racers participate in a resistance exercise program.

Furthermore, Gobbi et al. (2005) demonstrated an increase in blood lactate levels of motocross racers during riding. The recorded blood lactate levels were 5.3 mM. Similarly, Ascensao et al. (2008) reported blood lactate values of competitive motocross racers reaching 5.3mM. The observed lactate values suggest there is an anaerobic component to motocross racing. Moreover, it suggests the involvement of Type II muscle fibers. Type II muscle fibers are fast-twitch, anaerobic, glycolytic, lactate producing fibers that are activated for strength, power and quickness but fatigue more readily compared to Type I fibers (Kraemer et al. 1996; Kraemer & Ratamess, 2005). In motocross, fatigue is mainly due to the static involvement of several muscle groups concomitant with jumping and landing movements of the racer on the motorcycle. Fatigue produces a decrease in the muscular force necessary to oppose acceleration and deceleration forces during racing. It is one of the human factors that may limit performance in motor sports and therefore, should be considered in sport conditioning (Gobbi et al. 2005).

Sport conditioning can improve the fatigue characteristics of Type II muscle fibers. The appropriate resistance exercise can convert the more fatigue prone Type IIb fibers to the less fatigue prone Type IIa fibers (Kraemer & Ratamess, 2005). This would be beneficial to motorcycle racers that activate anaerobic metabolism during competition. Type IIa muscle fibers provide an optimal combination of strength, power and fatigue resistance. Therefore, resistance exercise targeted to enhance Type IIa muscle fibers should be considered in sport conditioning.

5.4 UPPER BODY RESISTANCE EXERCISE

The current study attempted to reveal with specificity, what particular resistance exercises contribute to improved performance. Two upper body resistance exercises were significantly different between expert and novice motorcycle road racers. A significantly ($p < .05$) higher percentage of the novice class employed dumbbell flys and barbell bicep curls into their upper body resistance exercise routine compared to the expert class. It's peculiar, based on the classifications on the racers in the current study, novice racers had greater participation in certain upper body resistance exercises compared to expert racers. If there had been a significant difference demonstrated where the expert group utilized a particular exercise more than the novice group, we could infer that particular exercise may contribute to improve motorcycle road racing classification because the premise of the study was that expert racers have greater skill levels. As a result, we hesitate in concluding that employing dumbbell flys and barbell bicep curls translates into improved motorcycle road racing classification. However, research has shown in other sports that sport-specific upper body resistance training improves sport performance. Terbizan et al. (1996) reported significant improvements in upper body strength of softball players after 16 weeks of training in bicep curls (45.91kg to 58.92 kg), in tricep extensions (27.20 kg to 31.96 kg), in shoulder pullovers (36.72 kg to 51.69 kg), in latissimus pull downs (44.21 kg to 51.69 kg) and in shoulder presses (22.78 kg to 36.73 kg). These improvements were related to the physiological profiles associated with fastpitch softball.

5.5 LOWER BODY RESISTANCE EXERCISE

One lower body resistance exercise was significantly different between Expert and Novice motorcycle road racers. A significantly higher percentage of the novice class employed lunges into their lower body resistance exercise routine compared to the expert class. For reasons mentioned previously, this does not necessarily translate into improved motorcycle road racing classification or performance. However, research has shown in other sports that sport-specific lower body resistance training improves sport performance. Terbizan et al. (1996) reported significant improvements in lower body strength of softball players after 16 weeks of training in leg extensions (48.63 kg to 76.18 kg) and in leg curls (34.68 kg to 48.29 kg). These improvements were related to the physiological profiles associated with fastpitch softball.

The current investigation also attempted to capture data related to the number of repetitions and sets utilized by the expert and novice class. The figures in chapter 4 illustrate the varied combinations of repetitions and sets employed by both classes. The study was unable to statistically analyze volume of repetitions and sets data to ascertain if there was a significant difference between expert and novice racers; however, the figures do illustrate which repetitions and sets combinations were employed most by either class.

The study of resistance exercise has shown that varied combinations of repetitions and sets can lead to specific desired effects within skeletal muscle (ACSM, 2002; Kraemer et al., 1996; Werbom et al., 2007). Specific combinations of resistance, repetitions and sets can promote muscle strength, muscle power, muscle hypertrophy and/or muscle endurance. However, viewing the collected data on resistance exercise repetition and set combinations, we can only speculate the intended desired effect of these participants. With the collected data of the current investigation, it will be arduous to provide a definitive answer to what combination of repetitions and sets is most desirable for amateur motorcycle road racers to improve classification. The results of this investigation showed that many of our participants employed resistance training. Other investigations (Lephart et al. 2005; Szymanski et al. 2007; Lachowetz et al. 1998) support the notion that resistance training leads to improved performance and that sport specific resistance training has greater effects on performance. One can surmise that the benefits of sport conditioning would impact motorcycle road racing performance.

5.6 STRENGTHS, LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

A strength of the current study is that it is one of the first to attempt to characterize amateur motorcycle road racers. To our knowledge there has not been any other published research concerning the characterization of these athletes. The investigation can provide a base for other studies to build upon and may serve as a starting point to understanding the physical characteristics of motorcycle road racers. Another strength of the current investigation was the accessibility of the survey to potential subjects. Conducting an online survey permitted participation from various geographical regions and provided convenience to potential subjects. However, this study is not without limitations and may affect the applications of the findings. The following is a list of limitations and recommendations for future research:

1. This study was based on the premise that Expert and Novice amateur motorcycle road racers have significantly different skill levels. However, it cannot be confirmed that this premise is true. Classification of riders by WERA states that Novices finishing in the top 3 in any of their Sportsman classes at the Grand National Finals and/or in the top five in points in any class in any region will be advanced to Expert status the following season. It may be possible in the current study that novices were the top performers in their class and the experts were the lowest performers of their class, which would limit the difference in performance ability between these classes of riders. This would require a direct measure of racing performance on a similar racing circuit (e.g. racing times), which was not available for this study. Future studies should include common measures of performance to establish definitive performance ability to compare data and ascertain contributions to motorcycle road racing performance.
2. The current study required a sample size of 144 subjects for a medium effect size (d= .5) and a sample size of 58 subjects for a large effect size (d= .8). Despite repeated efforts, we were only able to recruit 53 subjects, which may have resulted in this study being underpowered. Future investigations in this area of research should be adequately powered to examine proposed research hypotheses.
3. The assessment instrument used in this study was an online survey. Thus, there were no direct measures of maximal oxygen consumption, muscular strength, muscular power, body fat percentage or agility. Moreover, the validity and reliability of the survey instrument that was used has not been established specifically for motorcycle road racers. Future investigations should directly assess common sport-conditioning variables to establish a basis for which to compare to other sports and use survey instruments that have been validated for this unique population group.

4. This study relied on self-reported height and weight. Studies indicate that there is common trend to over-report height and under-report weight (Avila-Funes et al., 2004; Huber, 2007; Kuczmarski et al., 2001). Such over- and under-reporting may have contributed to inaccurate data in this study. Additionally, heart rate was self-reported. Although validity of the palpation technique to assess heart rate has been proven to be a viable tool in accurately assessing heart rate (Pollock et al. 1972; DeVan et al. 2004), we are unable to confirm if the subjects in the current study used the appropriate technique, which may have resulted in errors in the measurement of resting heart rate. Future studies should utilize direct measure of height, weight, and resting heart rate to improve the accuracy of these data.
5. This study recruited amateur motorcycle road racers. Thus, these individuals are not professional road racers. Therefore, subjects in the current study may not represent the true performance characteristics involved in highly skilled motorcycle road racers. Future studies should focus on the examination of professional motorcycle road racers when examining training techniques that may be associated with improved performance.
6. The exercise training patterns section of survey was developed by the investigator and has not been evaluated for validity and reliability. Further evaluation of this assessment method is required prior to use in future studies.

5.7 SUMMARY

The results of this study did not definitively support the hypothesis that there is a significant difference in the outcome variables between Expert and Novice amateur motorcycle road racers. While there were some differences between the Novice and Expert amateur motorcycle road racers, these findings do not provide sufficient information to conclusively develop a sport specific exercise program for motorcycle road racing. However, this study did illustrate similarities between the amateur motorcycle road racers and other motor sports for BMI and estimated maximal aerobic capacity (Konttinen et al. 2008; Gobbi et al. 2005; Ascensao et al., 2008).

The available scientific literature pertaining to motorcycle road racing is limited to identification of the types of physical injuries sustained by athletes participating in this sport (Tomida et al. 2005). Thus, this study provides some of the only data available with regard to training programs undertaken by motorcycle road racers. Therefore, additional research is necessary to fully understand characteristics and training regimens that are associated with improved motorcycle road racing performance.

APPENDIX A

GLOBAL PHYSICAL ACTIVITY QUESTIONAIRE

Physical Activity			
Please answer these questions even if you do not consider yourself to be a physically active person. Think first about the time you spend doing work. Think of work as the things that you have to do such as paid or unpaid work, study/training, household chores, harvesting food/crops, fishing or hunting for food or seeking employment. In answering the following questions 'vigorous-intensity activities' are activities that require hard physical effort and cause large increases in breathing or heart rate, 'moderate-intensity activities' are activities that require moderate physical effort and cause small increases in breathing or heart rate.			
Questions		Response	Code
Activity at work			
1	Does your work involve vigorous-intensity activity that causes large increases in breathing or heart rate like [carrying or lifting heavy loads, digging or construction work] for at least 10 minutes continuously?	Yes 1 No 2 if no, go to question 4	P1
2	In a typical week, on how many days do you do vigorous-intensity activities as part of your work?	Number of days ______	P2
3	How much time do you spend doing vigorous-intensity activities at work on a typical day?	Hours : minutes _____ : _____ hrs mins	P3 (a-b)
4	Does your work involve moderate-intensity activity that causes small increases in breathing or heart rate such as brisk walking [or carrying light loads] for at least 10 minutes continuously?	Yes 1 No 2 If no, go to question 7	P 4
5	In a typical week, on how many days do you do moderate-intensity activities as part of your work?	Number of days ______	P5
6	How much time do you spend doing moderate-intensity activities at work on a typical day?	Hours : minutes _____ : _____ hrs mins	P6 (a-b)
Travel to and from places			
The next questions exclude the physical activities at work that you have already mentioned. The following questions are about the usual way you travel to and from places. For example, to work, for shopping, to market or to place of worship.			
7	Do you walk or use a bicycle for at least 10 minutes continuously to get to and from places?	Yes 1 No 2 If no, go to question 10	P7
8	In a typical week, on how many days do you walk or bicycle for at least 10 minutes continuously to get to and from places?	Number of days ______	P8
9	How much time do you spend walking or bicycling for traveling on a typical day?	Hours : minutes _____ : _____ hrs mins	P9 (a-b)

Recreational Activities			
The next questions exclude the work and transport activities that you have already mentioned. The following questions are about sports, fitness and recreational activities (leisure).			
10	Do you do any vigorous-intensity sports, fitness or recreational (leisure) activities that cause large increases in breathing or heart rate like running or football for at least 10 minutes continuously?	Yes 1 No 2 If no, go to question 13	P10
11	In a typical week, how many days do you do vigorous–intensity sports, fitness or recreational (leisure) activities?	Number of days ______	P11
12	How much time do you spend doing vigorous-intensity sports, fitness or recreational (leisure) activities on a typical day?	Hours : minutes _____ : _____ hrs mins	P12
13	Do you do any moderate-intensity sports, fitness or recreational (leisure) activities that cause a small increase in breathing or heart rate such as brisk walking, cycling, swimming or volleyball for at least 10 minutes continuously?	Yes 1 No 2 If no, go to question 16	P13
14	In a typical week, on how many days do you do moderate-intensity sports, fitness or recreational (leisure) activities on a typical day?	Number of days ______	P14
15	How much time do you spend doing moderate-intensity sports, fitness or recreational (leisure) activities on a typical day?	Hours : minutes _____ : _____ hrs mins	P15
Sedentary Behavior			
The following question is about sitting or reclining at work, at home, getting to and from places, or with friends including time spent sitting at a desk, sitting with friends, traveling in car, bus, train, reading, playing cards or watching television, but do not include time spent sleeping.			
16	How much time do you usually spend sitting or relining on a typical day?	Hours : minutes _____ : _____ hrs mins	P16 (a-b)

APPENDIX B

CARDIORESPIRATORY FITNESS QUESTIONAIRE

The following questions are used to calculate an estimate of your Cardiorespiratory fitness.

Physical activity score: Choose <u>one</u> activity category that best describes your usual pattern of daily physical activities, including activities related to house and family care, transportation, occupation, exercise and wellness, and leisure or recreational purposes. Please check <u>one</u> box.

☐ LEVEL 1: In active or little activity other than usual daily activities.

☐ LEVEL 2: Regular (≥5 days/week) participation in physical activity requiring low levels of exertion that result in slight increases in breathing and heart rate for at least **10 minutes** at a time.

☐ LEVEL 3: Participate in aerobic exercises such as brisk walking, hogging or running, cycling, swimming, or vigorous sports at a comfortable pace or other activities requiring similar levels of exertion for **20 to 60 minutes** per week.

☐ LEVEL 4: Participate in aerobic exercises such as brisk walking, jogging or running at a comfortable pace, or other activities requiring similar levels of exertion for **1 to 3 hours** per week.

☐ LEVEL 5: Participate in aerobic exercises such as brisk walking, jogging or running at a comfortable pace, or other activities requiring similar levels of exertion for **over 3 hours** per week.

Please enter the correct response to the following questions.

1. Enter ‘0’ for woman or ‘1’ for man _______

2. Enter **age** in years _______

3. Enter **resting heart rate** _______

Calculate your resting heart rate: *To take your pulse, gently press your index and middle finger on the carotid artery in your neck or your radial artery in your wrist. You may have to shift positions several times to find the best position to feel your pulse. (Don't use your thumb to check your pulse.) Once you locate your pulse, count the number of beats you feel within 15 seconds and multiply that number by 4. It is best to calculate your resting heart rate in the morning prior to doing any activities.*
First paragraph.

APPENDIX C

EXERCISE TRAINING SUPPLEMENTAL QUESTIONAIRE

1. Do you participate in cardiorespiratory/aerobic exercise? _____ yes _____ no

   If yes, check all that apply: _____ jogging _____ cycling _____ swimming
   _____ rowing _____ elliptical glider _____ other

   If yes, how many days per week? _____ 1-2 days/week
   _____ 3-4 days/week
   _____ 5-7 days/week

   If yes, what is the typical duration? _____ 5-15 minutes
   _____ 16-30 minutes
   _____ 31-45 minutes
   _____ 46 or more minutes

2. On a scale of 1 to 10 (10 being the greatest), how much does aerobic exercise contributed to your racing performance?

   1:___ 2:___ 3:___ 4:___ 5:___ 6:___ 7:___ 8:___ 9:___ 10:___

3. Do you participate in resistance exercise/weight training? _____ yes _____ no

   If yes, check all that apply: _____ free weights _____ machines
   _____ calisthenics _____ resistance bands
   _____ other

   If yes, how many days per week? _____ 1-2 days/week
   _____ 3-4 days/week
   _____ 5-7 days/week

4. For which of the following do you perform resistance exercise (check all the apply)?

_____ shoulders	_____ legs	_____ upper back
_____ chest	_____ calves	_____ lower back
_____ arms	_____ stomach	_____ hand/forearms

5. Check all the following exercises that apply with the amount of resistance, repetitions (reps) and sets.

SHOULDERS

_____ Shoulder press (dumbbells):	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Shoulder press (barbell):	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Lateral Dumbbell raises:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Bent-over Dumbbell raises:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Upright rows:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +

CHEST

_____ Bench press (dumbbells):	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Bench press (barbell):	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
____ Dumbbell flys:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +

ARMS

_____ Bicep curls (dumbbells):	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Bicep curls (barbell):	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Wrist curls:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Reverse wrist curls:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Tricep push downs:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Tricep extensions:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +

UPPER BACK

_____ Lat pull downs:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +
_____ Seated rows:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +

LOWER BACK

_____ Deadlifts:	REPS: _____ 1-6	SETS: _____ 1-3
	_____ 7-12	_____ 4-6
	_____ 13 +	_____ 7 +

_____ Back extensions:	REPS:	_____ 1-6	SETS:	_____ 1-3
		_____ 7-12		_____ 4-6
		_____ 13 +		_____ 7 +

STOMACH

_____ Crunches:	REPS:	_____ 15-25	SETS:	_____ 1-3
		_____ 26-35		_____ 4-6
		_____ 36 +		_____ 7 +
_____ Sit-ups:	REPS:	_____ 15-25	SETS:	_____ 1-3
		_____ 26-35		_____ 4-6
		_____ 36 +		_____ 7 +
_____ Leg raises	REPS:	_____ 15-25	SETS:	_____ 1-3
		_____ 26-35		_____ 4-6
		_____ 36 +		_____ 7 +

LEGS

_____ Squats (dumbbell):	REPS:	_____ 1-6	SETS:	_____ 1-3
		_____ 7-12		_____ 4-6
		_____ 13 +		_____ 7 +
_____ Squats (barbell):	REPS:	_____ 1-6	SETS:	_____ 1-3
		_____ 7-12		_____ 4-6
		_____ 13 +		_____ 7 +
_____ Lunges:	REPS:	_____ 1-6	SETS:	_____ 1-3
		_____ 7-12		_____ 4-6
		_____ 13 +		_____ 7 +
_____ Leg press:	REPS:	_____ 1-6	SETS:	_____ 1-3
		_____ 7-12		_____ 4-6
		_____ 13 +		_____ 7 +
_____ Leg curls:	REPS:	_____ 1-6	SETS:	_____ 1-3
		_____ 7-12		_____ 4-6
		_____ 13 +		_____7+

CALVES

_____ Standing calf raises: REPS: _____ 1-6 SETS: _____ 1-3
_____ 7-12 _____ 4-6
_____ 13 + _____ 7 +

_____ Seated calf raises: REPS: _____ 1-6 SETS: _____ 1-3
_____ 7-12 _____ 4-6
_____ 13 + _____ 7 +

_____ Donkey calf raises: REPS: _____ 1-6 SETS: _____ 1-3
_____ 7-12 _____ 4-6
_____ 13 + _____ 7 +

6. On a scale of 1 to 10 (10 being the greatest), how much does resistance exercise contributed to your racing performance?

   1:___ 2:___ 3:___ 4:___ 5:___ 6:___ 7:___ 8:___ 9:___ 10:___

7. Has your exercise training pattern changed since the end of the 2009 racing season?
   _____ yes _____ no

8. In what manner has your exercise training pattern changed? Check all that apply
   _____ greater frequency per week _____ less frequency per week
   _____ longer durations _____ shorter durations
   _____ greater intensity _____ lesser intensity

ANTHROPOMETRIC INFORMATION

9. Please provide your anthropometric information
   Height: _____ feet _____ inches
   Weight: ___________ pounds

RACING INFORMATION

10. Type of Race motorcycle
Year:__________ Make:________________ Model:________________ Engine Size:__________

11. How many years have you been riding a motorcycle? _____ 1-3 years
_____ 4-5 years
_____ 6-9 years
_____ 10 + years

12. How many years have you been racing a sportbike on a track? ____ 1-3 years
____ 4-5 years
____ 6-9 years
____ 10 + years

13. Are you a Novice or Expert class racer? _____ Novice _____Expert

14. What WERA competitions do you race? Check all that apply

____ A Superstock	____ Light Weight Twins Superbike
____ A Superbike	____ Light Weight Twins Superstock
____ B Superstock	____ Heavy Weight Twins Superbike
____ B Superbike	____ Heavy Weight Twins Superstock
____ C Superstock	____ Formula 1
____ C Superbike	____ Formula 2
____ D Superstock	____ Solo Class Medium Weight C Superstock
____ D Superbike	____ Solo Class Medium Weight C Superbike
____ E Superstock	____ Solo Class Medium Weight Formula 2
____ E Superbike	
____ Other	

15. How many races have you competed in during the 2010 season? ____ 1-3 races
____ 4-5 races
____ 6-9 races
____ 10 +

16. List all tracks where you have raced during the 2010 racing season. Check all that apply.
____ Beaverun Motorsports Complex
____ Buttonwillow Raceway Park
____ California Speedway
____ Carolina Motorsports Complex
____ Gingerman Raceway
____ Grattan Raceway Park
____ Hallet Motor Racing Circuit
____ Jennings GP
____ Las Vegas Motor Speedway
____ Mid-Ohio Sports Car Course
____ Miller Motorsports Park
____ Nashville Superspeedway
____ Nelson Ledges Road Course
____ Road Atlanta
____ Roebling Road
____ Summit Point Raceway
____ Talladega Gran Prix Raceway
____ Virginia International Raceway

17. Do you have a sponsor for your motorcycle racing? ______ Yes ______No

If yes, who is your sponsor(s)? ____

What is the 2010 monetary contribution of your sponsor(s)? _______________

18. Do you have a mechanic? ______ Yes ______No

On a scale of 1 to 10 (10 being the greatest) how much does your mechanic contribute to your racing performance? __________

1:___ 2:___ 3:___ 4:___ 5:___ 6:___ 7:___ 8:___ 9:___ 10:___

19. Do you have a pit crew? __________

On a scale of 1 to 10 (10 being the greatest) how much does your pit crew contribute to your racing performance? __________

1:___ 2:___ 3:___ 4:___ 5:___ 6:___ 7:___ 8:___ 9:___ 10:___

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