

RECOVERY IN LEVEL 8-10 WOMEN'S
USA ARTISTIC GYMNASTICS

By

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A THESIS

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ABSTRACT

This study assessed physical performance in women's artistic gymnastics following three variable recovery periods. Participants included fifteen female gymnasts who had competed at USA Gymnastics (USAG) levels 8 – 10 within at least one year prior to the study. Each testing session consisted of a warm-up followed by four muscular endurance tests and one explosive maximal test. Assessments included pull-ups, leg lifts, handstand push-ups, push-ups and vertical jump. After the performance assessments, the participants completed a typical practice session. The performance measures were reassessed at the beginning of each of the recovery periods of 24, 48, and 72 hours in a counterbalanced design. Performance assessments were converted into Z-scores and then averaged for a composite session Z-score. The composite session Z-scores were compared to evaluate different durations of recovery. Composite Z's were significantly lower ($p=.000$), after the, 24 ($z=-1.10$) and the 48 hour ($z=-0.71$) recovery periods compared to baseline. However, there was no difference in scores ($p=1.00$) between the baseline and 72 hours ($z=0.004$) recovery. On average, full recovery required 72 hours under the conditions of this study.

Key words: rest, training recovery, performance measures

DEDICATION

This thesis is dedicated to my parents for providing the opportunity to attend the University. Also for the love and support through all of the trials and tribulation of my education and job search.

ACKNOWLEDGMENTS

I am pleased to have this opportunity to thank all of my colleagues, friends and faculty members who have helped with my research. I will never be able to repay Phillip A. Bishop, the chairman of this thesis, for sharing his research expertise and wisdom. I would also like to thank my committee members, Mark Richardson, and Kim Bissell for their input, questions, and support.

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CHAPTER 1

INTRODUCTION

Women's artistic gymnastics consists of a single routine performed on each of the four apparatus. Routines are composed of numerous skills that vary in difficulty and intensity on all of the events: floor, beam, uneven bars, and vault. The athlete has one chance at receiving the highest score (0 – 10) on each event during a competition. The performance of the athlete during a competition is critical. One mistake could lead to a loss of points or injury. To be prepared for competition, gymnasts train many hours per week on a year-round basis. Female gymnasts competing for a club at the sub-elite optional levels (USA Gymnastics, 7-10) maintain a high number of practice hours during both competitive and non-competitive seasons. Competitive clubs require their gymnasts, ages 10-17 years, to train 16-25 hours per week [3,7,13]. The gymnasts have to learn a wide variety of skills and have to be in excellent physical condition. The training volume and intensity may not allow enough time for full recovery [2]. Researchers have found that during training sessions, gymnasts perform routines while fatigued [5,6]. Unfortunately, when fatigued, there is a compromise between performance (perfect execution), safety, and maximal effort [5,6]. In most cases, gymnasts will preserve safety, so performance or maximal effort suffers as a result of fatigue.

Realistically, it is difficult for one variable to suffer and not the others. Overtraining of the gymnasts could be the cause of reduced performance in the gymnasts. McLester et al. showed that after 24 hours following a weight-lifting workout, the participants (recreational weight lifters) could not reproduce their original results [8]. This points toward insufficient recovery time in that group. It is possible that the typical ~24 hour period between workouts is insufficient for gymnasts as well.

The purpose of the present study was to determine at what whole-day of recovery duration (24,48,72 hrs) between a training session and a competition, or two training sessions, would allow for replication of an un-fatigued physical performance. This will better ensure that the athlete is completely recovered from the training session and will not have to compromise performance, safety, or effort. Gymnasts benefit most from a workout when they can perform it optimally, which requires full recovery. We hypothesized that full recovery in our Level 7-10 gymnasts would require more than 24 hours.

CHAPTER 2

METHODS

Subjects

Fifteen healthy female volunteer gymnasts (12 to 16 years of age) were recruited to participate in the study. The participants were recruited from 3 gymnastics facilities. To be eligible, the athletes must have competed at a sub-elite optional level (USAG levels 7-10) during the competitive season prior to the study. The distribution of the athletes by USAG Level were Level 7 (0), Level 8 (5), Level 9 (8), and Level 10 (2). All of the athlete's coaches reported that they practiced ≥ 20 hours per week. The participating gyms followed one of these practice schedules: Monday, Tuesday, Wednesday, Thursday, Friday; or Monday Tuesday, Thursday, Friday, Saturday.

The study was reviewed and approved by the Institutional Review Board. The athletes were asked not to participate in any other forms of exercise other than the testing protocol and their gymnastics training throughout the course of the study. They were also asked to maintain the same dietary habits as close as possible before and during the study. Before taking part in the study, all participants were briefed on the risks associated with the research. The athletes with the help from their legal guardians completed a Physical Activity Readiness Questionnaire (PAR-Q)[1], a Current Health Status Questionnaire and Training Status Questionnaire. Written Parental Informed Consent and participant assent were obtained. These were used to ensure that the athlete could safely complete the study and to assess their health risk.

Experimental Approach to the Problem

A training status questionnaire was administered to ensure that the athlete had participated at least one year at a USAG optional level. The questionnaire was also used to determine the competitive background of each individual gymnast (level competed at last season and number of years competed at that competitive level). Following the training status questionnaire, the gymnast's anthropometric data were collected (age, weight and percent body fat). Percent body-fat was estimated by using the three-site skin-fold test: triceps, abdominal, and thigh (Lange Calipers, Beta Technology Inc., Cambridge, MD) as described by Pollock, Schmidt, and Jackson [10]. The participants' anthropometric data can be seen in Table #1.

Observation of the athlete's training occurred at least 72 hours prior to testing. At the beginning of the observation period, the athletes performed a light jog followed by their normal routine of stretches. After completion of their warm-up, the athletes were then familiarized with the performance measures. Familiarization of the performance measures were identical to the test session procedures. After completion of the performance measures the gymnasts then completed their typical daily practice. During the practice, the gymnasts were observed in order to assess several training variables. The training variables that were recorded were time spent: warming up, stretching, basic tumbling, practicing each of the four events, and conditioning. The number of attempts on each apparatus, skills, routines, and amount of conditioning were also recorded. All of these training variables were used to recreate the training session and to maintain an equal workload for every test session. Although the amount of time for each training variable and number of attempts on each apparatus were different for each gym, the goal was to keep the gymnast in their normal routine but control their practice with the workload. After the observation period, the athlete was given 72 hours of rest to serve as a wash-out period before the recorded testing sessions. During each of the four testing sessions, the athletes performed the

amount of work that was observed during the preliminary observation session. All coaches cooperated with the data collection schedule an overall plan.

Experimental Design

The baseline session occurred 72 hours after the familiarization/observation period. The test sessions were separated by three different recovery periods: 24, 48, and 72 hours in counterbalanced order. At the beginning of each testing session, the participants performed a warm-up that was identical to the warm-up that was observed and recorded from the familiarization/observation session. No other skills were performed before the performance measures. After completion of the warm-up, the athlete performed the performance measures in a repeated measures design. The performance measures were used to evaluate recovery. The scores from the first test session were used as the athlete's baseline score and their recovered physical state. After completion of the performance measures, the gymnasts then completed a practice that consisted of the same workload recorded during the familiarization/observation period.

The performance measures are described in detail in Sands [11]. The descriptions can be seen below in Table #2. These descriptions are directly from Sands [11]. The five tests that were used for this research were: pull ups, leg lifts, handstand pushups, standing vertical jump, and pushups administered in that order. Standing vertical jump was tested differently than described in Sands et al, 1991 [11]. Standing vertical jump was tested with the use of a vertical jump test mat (Just Jump! Or Just Run!, Probotics Inc., Huntsville AL.). The athletes were given 3 attempts at performing their highest jump and the highest jump was recorded. For the remaining four tests, the athletes were given 60 seconds to complete as many repetitions as possible. The

athletes were given at least 2 minutes of rest in between each test and no more than 3 minutes.

These tests are illustrated in Figures 1-5 of Sands, [11]. Table #3 shows the schedule that the test sessions followed.

Statistical Analysis

The data that were entered in Microsoft Excel (2007). The performance measure scores were converted into Z-scores based on deviation from baseline scores and then averaged to obtain overall session Z-scores for each individual. Session Z-scores were input into SPSS for windows (v. 16) for all analyses. A repeated measures ANOVA was performed on all variables with an alpha level of $p \leq 0.05$.

CHAPTER 3

RESULTS

The recovery of the gymnasts was measured by converting their performance measure scores into a Z-score and then determining a composite averaged Z-score. Mean and standard deviation were determined from the first test session data and used as the baseline to calculate the Z-score for all of the recovery periods. The means and standard deviations for each measure can be seen in Table #4 along with the average composite score for each recovery period. Three of the participants had to repeat their baseline because of a faulty baseline. These three participants did not fully understand that they were to complete as many repetitions as possible for each performance measure. The group averages and standard deviations on each performance measure can be seen in Figure 1.1-1.5.

The level of recovery was determined by comparing the composite Z-scores to baseline. The composite Z's were entered into a multiple comparisons test to determine if there were any significant differences between the recovery periods. A Bonferroni post hoc procedure ($p \leq 0.05$) revealed significant differences between baseline (0.00) and 24 hours ($z = -1.10$) ($p = .000$) and also between baseline (0.00) and 48 hours (-0.71) ($p = .000$). There was also a significant difference between 24 (-1.10) and 48 hours (-0.71) ($p = .001$). The post hoc test also revealed that baseline ($z = 0.00$) and 72 hours (0.004) were not significantly different ($p = 1.00$) from each other. The 72 hour ($z = 0.004$) period was significantly different from 24 ($z = -1.10$) and 48 hours ($z = -0.71$) ($p = .000$).

Each performance measure was also analyzed between baseline, 24, 48 and 72 using a Repeated measures ANOVA with a Bonferroni post-hoc analysis. The analysis revealed that on every performance measure, the 24 and 48 hour periods were significantly different from the

baseline ($p=.000$). The analysis also showed for all of the performance measures except vertical jump ($p=0.024$) that the 72 hour period was not significantly different from the baseline ($p=1.00$).

Finally, due to the likelihood of individual differences in recovery among our participants, individual data were recorded. As can be seen in Table 5, participants # 4,5,8 and 11 appeared to be fully recovered by 48 hours based on their individual average z-scores.

CHAPTER 4

DISCUSSION

The purpose of the present study was to determine at what whole-day of recovery duration (24, 48, 72 hrs) between a training session and a competition, or two training sessions, would allow for replication of an un-fatigued physical performance. The results suggest that 72 hours of recovery was the shortest average recovery period for replicating physical performance within the limitations of this study and sample. The results revealed that there was, on average, a difference in the athlete's physical performance between baseline 24 and 48 hours of recovery. The results were also supported by the data from each individual performance measure.

After 24 ($z=-1.10$) and 48 ($z=-0.71$) hours of rest, the gymnast's performance showed a significant decrease in comparison to their baseline performance. This study was limited to female gymnasts between the ages 12-16 competing at sub-elite optional level 8-10 practicing an average of 20 hours per week.

Unfortunately, there are no published studies of training recovery in gymnasts. The current study was designed after a weight lifting study [8]. The weight lifting study investigated 4 time periods (24, 48, 72, 96 hrs) to determine which period allowed the lifter to fully recover from a series of muscular endurance exercises. The weight lifting study revealed that the majority of the lifters did not fully recover to their baseline performance until 72 hours after the lift. After the 48 hour period there were only 4 participants who were able to reproduce their baseline performance [8]. The logic behind that study was that if you had optimal recovery between training sessions, the lifter should be able to train at a higher intensity while preventing detraining. If the lifter could train at a higher intensity, then the benefit from each training session should be greater [2]. This same idea is applied to the current study. If the gymnast is not

fully recovered, then they will not be able to perform at the highest intensity in the subsequent meet or training session.

Analysis of individual responses suggest that 72 hour of rest between practices was needed for replicating physical performance for 11 of our 15 participants, with only 48 hours of recovery needed for the remaining four participants (see Table 5). Allowing the gymnasts to have 72 hours of total recovery between each training session would be extremely difficult, but certainly lighter- and heavier- work days could be interspersed in a periodization micro-cycle.

That is, the findings of this study could be applied to the workload of the gymnast. For example, the gymnast could have a very physically demanding practice at the beginning of the week, followed by two light practices. The difficult practice could consist of full routines, multiple skill sets, halves of routines, and rigorous conditioning. The light practices could focus on fundamentals, techniques, drills, flexibility, and single skills. The decreased workload should allow the gymnast to recover more completely, even though they are still training. Following the two light practices, would be a fatiguing practice. This schedule should generate peak physical performance for each of the difficult practices.

At peak physical performance, the athletes might increase the intensity of their workouts and improve the overall execution of their skills, also allowing the athlete to focus more on the mental aspects of the sport. This would be ideal for 11 of the 15 participants in our study. For the remaining four participants, the schedule could include a difficult practice every other day with a light practice in between.

These methods can also be used in preparation for a competition or the entire competition season. During the planning of the competition season, the coaches could determine the practice schedule based on the gymnast's recovery. If the coach plans the practices according to the

competition, this could allow their gymnasts to be fully recovered on the day of the competition. Plus, recovery characteristics of gymnasts could be re-assessed periodically throughout the season, using the techniques of this study.

Many coaches would argue against allowing 72 hours of recovery between practices or between practice and competition. They would argue that the gymnast would not be mentally prepared or that their timing would be off after 72 hours. This research did not test the mental state or the timing of the gymnasts. This investigation measured only the physical recovery of the gymnasts. Timing and mental preparation is important, but arguably physical performance is more important. If a gymnast is physically fatigued they will not be able to perform their skills to the best of their ability, regardless of timing or mental state. This could lead to a loss in points in a competition, injury, or overtraining.

Using the methods from the current study a coach can test their team and determine the appropriate recovery period for the team or for each one individually. McLester's weight lifting study found that recovery was variable among individuals [8]. It is very important to have the appropriate recovery period for individual athletes [2]. The same is true of gymnasts.

These results should not be generalized for all female gymnasts (beginners, compulsory, or collegiate). There were very similar trends among the participants but the optimal practice design would be based on each individual's needs.

According to previous research on gymnasts, during an intense session of training the gymnast must perform routines while fatigued. While fatigued the gymnast must compromise technique, intensity or safety [6]. The compromise of any of these three things could greatly decrease the overall performance and safety of the gymnast [6]. The compromise of technique or intensity could greatly affect the performance of the gymnast. If adequate recovery is not allotted

then the gymnast will begin the next training session with a lower capacity than the previous session, leading to a substantial decrease in performance.

In previous research it was stated that insufficient recovery could lead to injury [2]. The current research indirectly supports that claim. The decrease in the gymnast's performance was so large that at some point, the gymnast's safety could be compromised. A decrease in capacity would most likely affect their intensity first, then their technique. The loss of technique could very soon translate into the loss of safety resulting in a fatigue related injury [7, 12].

Practical Applications

This study was designed to assess training recovery in USAG gymnasts. We found that, for most of our gymnasts (11 of 15), 72 hours of recovery between hard workouts was needed for physical recovery. A secondary application of this study is as an effective method of measuring recovery in USAG female athletes. The methods of this study could be practically applied to teams and individuals. The application of these methods could allow the coaches and the gymnasts alike to develop an individual workout schedule for peak performance.

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Table #1 *Anthropometric Data (n=15).*

	Age (yrs)	Weight (Kg)	Body Fat % (3 skinfolds)	Yrs at USAG Optional Level
Mean	13.5	46.6	11.4	3.6
SD	1.1	8.9	2.6	1.7

Table #2 *Descriptions of Performance Measures*

Pull-ups	The gymnast started in a full hang with an overgrip on the upper bar of the uneven parallel bars. A complete pull-up is a rise from a full hang to a flex arm position with the chin above the bar. The tester was positioned to the side of the gymnast and placed a hand on the lower back of the gymnast to ensure that they did not swing to start their pull-up. One repetition was count each time the gymnasts pulled from a full hang to their chin above the bar.
Leg Lifts	The gymnast started from a full hanging position with an overgrip on the upper bar of the uneven parallel bars. The tester stood beside the gymnast and places a hand on the back of the gymnast and pressed forward to prevent the gymnast from swinging during the test. The tester also watched from the side to see if the gymnast's feet touched the bar. One repetition was counted each time the gymnasts touched their feet to the bar by pulling their legs and touching their feet to the bar.
Handstand Push-ups	The gymnast kicked to a handstand on the edge of a panel mat so her finger tips could go over the front edge. Next to the front edge of the panel mat was an 8 inch landing mat to serve as a place for the gymnasts to touch their forehead during each repetition. The

	gymnast was supported at the legs by the tester to help her keep balanced. The tester did not assist the gymnasts but kept her in the upright position. One repetition was counted each time the gymnast lowered her head and touched the mat.
Vertical Jump	The use of a vertical jump test mat was used to measure the height of the jump (Just Jump! Or Just Run!, Probotics Inc., Huntsville AL.). The gymnast performed three vertical jumps by swing their arms, bending their legs and then extending them and then jumping with arms extended over their head. The gymnasts were allowed to reset their feet before completing each jump. The best jump was recorded.
Push-ups	The gymnast started in a good hollow body push-up position. The corner of a 4 inch landing mat was used to place between the hands of the gymnast directly under the forehead. One repetition was counted each time the gymnast lowered her body in a good hollow body position and touched her forehead on the mat and then pushed back to the starting position.

- The gymnasts were given 60 seconds to complete as many repetitions as possible for each test excluding vertical jump.

From Sands, W.A. Injury Prevention in Women's Gymnastics. *Sports Medicine*: 30: 359-373, 2000.

Table #3 Chronological Testing Sequence

Amount of Time Spent	Activity
20 Minutes	Light Jog and Stretch

60 Seconds	Pull-up Test
2-3 Minutes	Rest
60 Seconds	Leg Lift Test
2-3 Minutes	Rest
60 Seconds	Handstand Push-up Test
2-3 Minutes	Rest
3 Jumps/30-60 Seconds	Vertical Jump Test
2-3 Minutes	Rest
60 Seconds	Push-up Test
3-3.5 Hours	Monitored Workload Practice

Table #4 Means, standard deviations, and composite Z-scores of performance measurements for Level 8-10 gymnasts (n=15).

	Pull-ups	Leg Lifts	Handstand Push-ups	Vertical Jump	Push-ups	Composite Z-Score
Baseline	15.60 ± 3.52	18.53 ± 3.09	18.13 ± 5.11	21.01 ± 2.89	64.27 ± 12.66	0.00
24 Hours	10.13 ± 3.14	14.60 ± 3.07	11.00 ± 4.75	19.95 ± 2.84	52.40 ± 12.99	-1.10
48 Hours	12.33 ± 3.27	15.80 ± 3.61	13.20 ± 5.13	20.37 ± 2.95	56.93 ± 11.12	-0.71
72 Hours	15.2 ± 3.9	18.73 ± 3.45	18.53 ± 4.96	20.67 ± 2.75	65.73 ± 11.83	0.004

Table #5 *Individual Session Z-scores*

Participant	Baseline Session	24 Hours	48 Hours	72 Hours
1	-0.46	-1.31	-1.08	-0.37
2	-0.04	-0.96	-0.87	0.31
3	-0.56	-1.42	-1.21	-0.66
4	0.7	0.00	0.1	0.65
5	1.15	0.06	0.47	1.18
6	-0.07	-1.21	-0.78	-0.05
7	-1.63	-2.49	-2.33	-1.53
8	0.84	-0.69	0.01	0.9
9	0.65	-0.71	-0.15	0.72
10	-0.25	-1.34	-1.12	-0.12
11	0.9	-0.32	0.27	0.89
12	-0.52	-1.82	-1.37	-0.64
13	0.11	-1.15	-0.65	-0.23
14	-0.67	-1.82	-1.33	-0.72
15	-0.15	-1.28	-0.72	-0.21

Figure #1.1

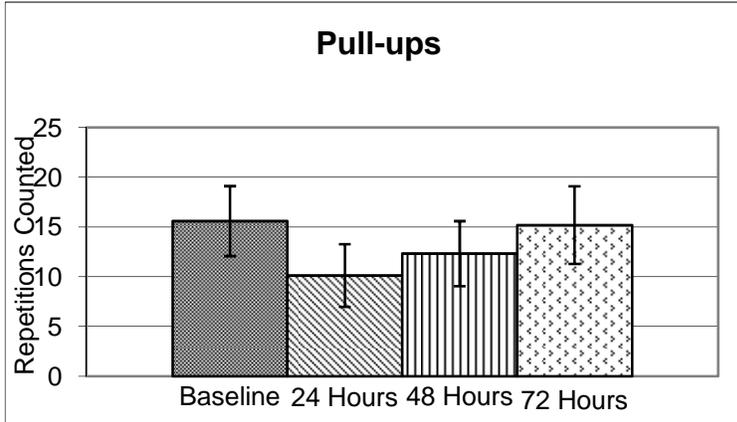


Figure #1.2

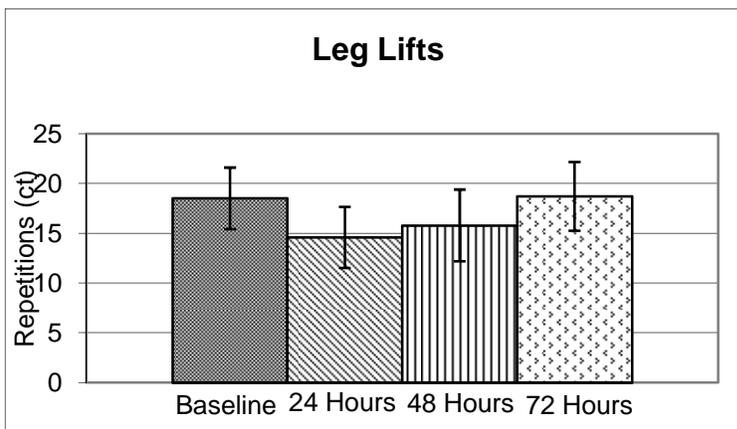


Figure #1.3

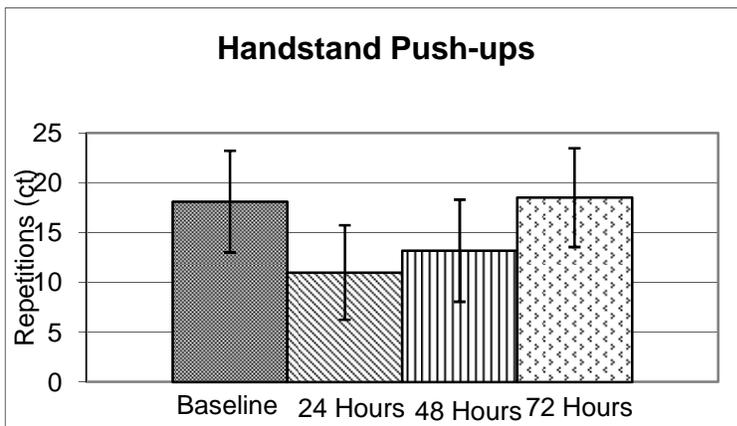


Figure #1.4

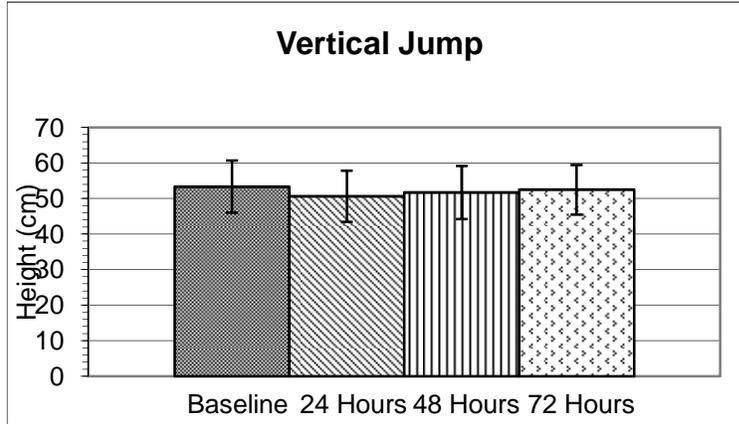


Figure #1.5

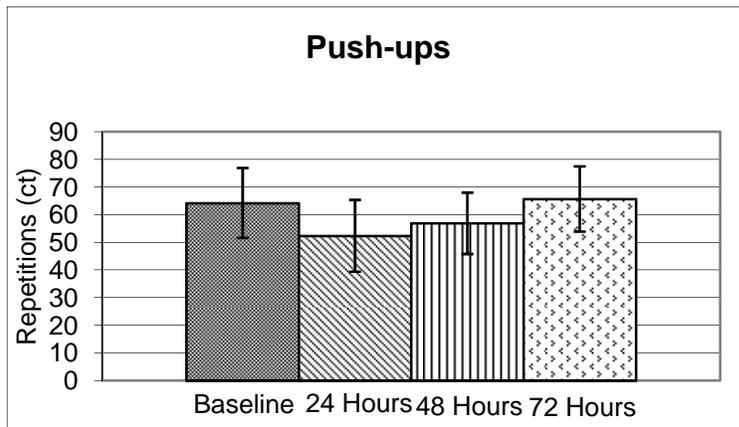


TABLE CAPTIONS

- 1 Anthropometric Data
- 2 Descriptions of Performance Measures
- 3 Chronological Testing
- 4 Means, Standard Deviations and Composite Z-Scores
- 5 Subject's Individual Session Z-Scores

FIGURE CAPTIONS

- 1.1 Average Pull-ups with Standard Deviation (n=15)
- 1.2 Average Leg Lifts with Standard Deviation (n=15)
- 1.3 Average Handstand Push-ups with Standard Deviation (n=15)
- 1.4 Average Vertical Jump Height with Standard Deviation (n=15)
- 1.5 Average Push-ups with Standard Deviation (n=15)