International Journal of EXERCISE SCIENCE

Original Research

RECOVERY IN LEVEL 7-10 WOMEN'S USA ARTISTIC GYMNASTICS

STEPHEN B. BUCKNER†[1], NICHOLAS T. BACON‡[2], and PHILLIP A. BISHOP‡[3]

[1]Athletics Department, Arizona State University, Tempe, AZ, USA; [2]Department of Sports Science, Belmont University, Nashville, TN, USA; [3]Department of Kinesiology, University of Alabama, Tuscaloosa, AL, USA

†Denotes graduate student author, ‡Denotes professional author

ABSTRACT

International Journal of Exercise Science 10(5): 734-742, 2017. This study assessed physical performance in women's artistic gymnastics following three variable recovery periods. Participants included fifteen female gymnasts (mean age = 13.5 ± 1.1) who had competed at USA Gymnastics (USAG) levels 7 – 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, vertical jump, and push-ups. 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 the recovery duration. Composite Z's were significantly lower (p=0.000), after the 24 (z=-1.10) and the 48 hour (z=-0.71) recovery periods compared to baseline (z=0.00). However, there was no difference in scores (p=1.00) between the baseline and 72 hours (z=0.004) recovery. Full recovery required 72 hours under the conditions of this study.

KEY WORDS: Rest, training recovery, performance measures

INTRODUCTION

Women's artistic gymnastics consists of a single routine performed on each of the four apparati. Routines are composed of numerous skills that vary in difficulty and intensity: 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 numerous hours per week on a year-round basis. A gymnastic strength-training session will often include a combination of unilateral, bilateral, contralateral ipsilateral, isotonic and/or isometric exercises. Thus, numerous variations of handstands, push-ups, leg lifts, jumps, pull-ups, and squats exist within a gymnastic strength-training session. 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, 7,1 3). The gymnasts have to learn a wide variety of skills and have to be in excellent physical condition. The training volume 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 (risk of injury), and maximal effort. In most cases, gymnasts will preserve well-being, so performance or maximal effort suffers as a result of fatigue (5, 6).

Prolonged fatigue could be the cause of reduced performance and effort 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. Gymnastics, much like weight-lifting, is primarily an anaerobic activity. Events such as the floor exercise include maximal efforts throughout a floor routine lasting no more than 90 seconds. However, from the best of our knowledge no previous studies have examined how recovery time between workout sessions may impact performance.

The purpose of the present study was to determine the minimum recovery period between a training session and a competition. An additional purpose was to investigate whether two training sessions that will allow for replication of an un-fatigued physical performance determined by scored performance measures. This will better ensure that the athlete is completely recovered from the training session and will not have to compromise performance, well-being, or effort. We hypothesized that full recovery in our Level 7-10 gymnasts would require more than 24 hours.

METHODS

Participants

Fifteen healthy female volunteer gymnasts, between 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, and workload was considered heavy, as they were all four months from beginning their competitive-season. The participating gyms followed one of these practice schedules (Monday, Tuesday, Wednesday, Thursday, Friday or Monday Tuesday, Thursday, Friday, Saturday).

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. Each gym was observed to ensure that the training performed outside of the study was comparable. They were also asked to maintain the same dietary habits as close as possible before and during the study. The study was reviewed and approved by the Institutional Review Board at the University of Alabama. Before taking part in the study, all participants were briefly introduced to 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 an Assent Form was obtained. This was used to ensure that the athlete could safely complete the study and to assess their health risk.

Protocol

A training status questionnaire (TSQ) 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). The TSQ included questions such as: How many years have you participated in gymnastics, How many years have you competed at the optional level, What level did you compete at this season, How many years have you competed at that level, What was your highest all-around score from this season, and What is your favorite event? Following the TSQ the gymnast's demographic data (age) and anthropometric data were collected (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 average estimated percentage of body fat was 11.4% with a standard deviation of 2.6%. The participants' demographic and anthropometric data can be seen in Table 1.

Table 1. Anthropometric data and demographic (n = 15). Data shown as Mean ± SD.

Age (yrs)	13.5 ± 1.1
Weight (Kg)	46.6 ± 8.9
Body Fat %	11.4 ± 2.6
USAG Optional Level	3.6 ± 1.7

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 warm-up consisting of 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 through verbal instruction. Then, the performance measures were completed 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 to assess several training variables. The training variables collected 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 was different for each gym, the idea 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 complete rest as a recovery period before the next recorded testing sessions. During each of the four testing sessions, the athletes performed the same amount of work which was observed during the preliminary observation session.

The baseline session occurred 72 hours after the familiarization/observation period. The test sessions were separated by three variable 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 executed the performance skills that were used to evaluate recovery in a repeated measures design. 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.

Table 2. Chronological test 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

The performance measures are described in detail in Sands, Physical Abilities Field Tests U.S. Gymnastics Federation Women's National Teams (11). The five tests that were used for this research were: pull ups, leg lifts, handstand pushups, standing vertical jump, and pushups administered in this order. It is believed these measures, in their singularity or combination of, have a direct effect on the four gymnastic events: floor (pushups, handstands, vertical jump), beam (handstands, leg lifts), uneven bars (pull-ups; handstands), and vault (handstands, vertical jump height). Furthermore, due the movement complexity and variation of an individualized performance-routine, it is difficult to quantify. Therefore it is assumed that simple movement patterns, such as pull-ups, leg lifts, handstand pushups, vertical jumps, and pushups lay the foundation of gymnastics performance. The current authors are in support of the aforementioned five tests that are well practiced among gymnasts, and thus influence gymnastics performance. 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 where 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. These tests are illustrated in Figures 1-5 of Sands, (11). Table 2 shows the schedule that the test sessions followed.

Statistical Analysis

The data were collected and computed 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) to perform all analyses. A one-way repeated measures ANOVA was performed across 4 levels of time (baseline, 24, 48 and 72 hours) on all dependent variables with an alpha level of $P \leq 0.05$. The elapsed time since the previous workout served as the independent variable and the five performance tests were the key dependent variables.

RESULTS

The recovery of the gymnasts was measured by converting their performance measure scores into a Z-score and then determining a composite Z-score. Mean and standard deviation were determined for the first test session and used as the baseline to determine the Z-score for all of the recovery periods. The means and standard deviations for each measure can be seen in Table 3 along with the average composite score for each recovery period. Three of the participants had to repeat their baseline because of a faulty baseline, for baseline values were lower than the values obtained in the familiarization/observation period. The group averages and standard deviations on each performance measure can be seen in Table 3. The participant's individual session z-scores can been seen in Table 4.

Table 3. Means, standard deviations, and composite Z-scores of performance measurements for Level 8-10 gymnasts (n=15).

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

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 post hoc procedure with a Bonferroni correction ($P \leq 0.05$) revealed significant differences between baseline (0.00) and 24 hours (-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 (0.00) and 72 hours (0.004) were not significantly different ($p=1.00$). The 72 hour (0.004) period was significantly different from 24 (-1.10) and 48 hours (-0.71) ($p=.000$).

Table 4. Individual session Z-scores.

Participant	Baseline Session	24 hrs	48 hrs	72 hrs
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

DISCUSSION

The purpose of this study was to determine which of the three recovery periods (24,48,72) leads female gymnast to produce a greater performance. The results suggest that 72 hours of recovery was the ideal recovery period for optimum physical performance within the limitations of this study and sample. The results revealed that there was a difference in the athlete's physical performance between baseline 24 and 48 hours of recovery.

After 24 (-1.10) and 48 (-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 as it relates to gymnastics training and recovery.. The current study was designed after a weight lifting study. The weight lifting study investigated 4 time periods (24, 48, 72, 96) 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 out of the 15 participants that 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 can 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.

Analysis of individual responses suggest that 72 hours of rest between practices was crucial for peak physical performance for 11 of the 15 gymnasts, with only 48 hours of recovery needed for the remaining four gymnasts. Peak performance defined is considered the maximal number of repetitions completed in the previous muscular endurance tests. Allowing the gymnasts to have 72 hours of total recovery between each training session would be extremely difficult, but certainly lighter and heavier workdays could be interspersed.

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 difficult conditioning. The light practices could focus on fundamentals, techniques, drills, flexibility, and single skills. The decreased workload should allow the gymnast to recover while still working to improve other technical aspects of performance. Following the two light practices should be a difficult practice. This schedule should generate peak physical performance for each of the difficult practices.

These methods can also be used in preparation for a competition. During the planning of the competitive season, the coaches could determine the practice schedule based on the gymnast's acute recovery response. Thus allowing 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.

Using the methods from the current study, a coach can test their team and determine the appropriate recovery period for individuals. 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. A limitation to the study would be how often the gymnasts practice these five tests: pull ups, leg lifts, handstand pushups, standing vertical jump, and pushups. However it should be noted, that a variation of these simple patterns are evident in a more complex gymnastics routine, and therefore lay the foundation for gymnastics performance. In addition to performance testing, future recovery studies should measure biomarkers of fatigue.

According to previous research on gymnasts, during an intense session of training the gymnast often perform routines while fatigued. While fatigued the gymnast must compromise technique and intensity or increase their risk of injury (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.

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 recovery method and application of this study could be practically applied to teams and individuals. As most athletes in this study were recovered at 72 hours, there were some athletes that were fully-recovered at 48 hours. It could allow the coaches and the gymnasts alike to understand the ideal workout schedule for peak performance.

ACKNOWLEDGEMENTS

We are pleased to have this opportunity to thank all of our colleagues, friends and faculty members who have helped with this research. We will never be able to repay the chairman of this study, for sharing his research expertise and wisdom. We would also like to thank Mark Richardson and Kim Bissell for their input, questions and support. This research would not have been possible without the support of family, friends, and fellow graduate students. Finally, we would like to thank all of the volunteer gymnasts and the coach for allowing us to work with them during their training season.

REFERENCES

1. Armstrong, L. et al. ACSM's Guidelines for Exercise Testing and Prescription. New York, NY: Lippincott Williams & Wilkins, 2006.

2. Bishop, PA, Jones, E, and Woods, AK. Recovery From Training: A Brief Review. J Strength Cond Res 22(3): 1015-1024, 2008.

3. Daly RM, Bass SL, Finch CF. Balance the risk of injury to gymnasts: how effective are the counter measures? Br J Sports Med 35: 8-20, 2001.

4. Goswami A, Gupta S. Cardiovascular stress and lactate formation during gymnastic routines. J Sports Med Phys Fitness 38: 317-322, 1998.

5. Jemni M, Sands WA, Friemel F, Le Chevalier JM. Heart Rate and blood lactate concentration as training indices for high level men's gymnasts. http://www.ginasticas.com/conteudo/gimnica/gin_artistica/ginasticas_com_gimnica_fisiologia_gam_congreso_anaheim_2003.pdf Accessed on 11/18/2009

6. Jemni M, Sands WA, Friemel F, Delamarche P. Effect of active and passive recovery on blood lactate and performance during simulated competition in high level gymnasts. Can Soc Exerc Physiol 28(2): 240-256, 2003.

7. Kolt GS, Kirkby RJ. Epidemiology of injury in elite and subelite female gymnasts: a comparison of retrospective and prospective findings. Br J Sports Med 33: 312-318, 1999.

8. McLester JR, Bishop PA, Smith J, Wyers L, Dale B, Kozusko J, Richardson M, Nevett M, Lomax R. A Series of Studies- A Practical Protocol for Testing Muscular Endurance Recovery. J Strength Cond Res 17(2): 259-273, 2003.

9. Montgomery DL, Beaudin PA. Blood lactate and heart rate response of young females during gymnastic routines. J Sports Med 22: 358-365, 1982.

10. Pollock M, Schmidt D, Jackson A. Measurement of cardiorespiratory fitness and body composition in the clinical setting. Comp Ther 6: 12-27, 1980.

11. Sands WA, Mikesky AE, Edwards JE. Physical abilities field tests U.S. gymnastics federation women's national teams. USGF Sport Sci Congress 1: 39-47, 1991.

12. Sands WA. Injury Prevention in Women's Gymnastics. Sports Med 30: 359-373, 2000.

13. Weiss WM, Weiss MR. Sport Commitment Among Competitive Female Gymnasts: A Developmental Perspective. Res Q for Exerc Sport 78(1): 90-102, 2007.