Development and Validation of a Swimmer's Functional Pain Scale

Shawn M. Drake[1], Brian Krabak[2], George T. Edelman[3], Erin Pounders[1], Sharmon Robinson[1], Brittany Wixson[1]

[1]Arkansas State University
PO Box 910
Jonesboro (State University), Arkansas, USA

[2]Rehabilitation, Orthopedics and Sports Medicine
University of Washington and Seattle Children's Sports Medicine
1959 N.E. Pacific Street
Seattle, Washington, USA

[3]99 Wolf Creek Blvd., Suite 2
Dover, Delaware, USA

Abstract

Swimmers frequently complain of shoulder pain sometime during their careers. The purpose of this study was to develop and validate a self-administered questionnaire that measures pain and functional status of the shoulder in swimmers that may alert a coach or swimmer to seek follow up with a healthcare provider. Participants completed the developed Swimmer's Functional Pain Scale (SFPS) and Kerlan-Jobe Orthopaedic Clinical Overhead Athlete Shoulder and Elbow (KJOC) questionnaires on two separate occasions (pre and post). Fifty-eight USA Swimming age group and collegiate swimmers (n=58) completed the test-retest design measuring the SFPS. Results of this study indicated that the SFPS is a valid and reliable tool for swimmers to determine when a referral to a healthcare provider is appropriate.

Introduction

Competitive swimmers place high demands on the upper extremity, especially the shoulder joint, by excessive shoulder revolutions and power strokes. Sein et al. (2010) reported that competitive swimmers typically complete 2500 upper extremity revolutions per day during swim practice. Furthermore, repetitive and forceful overhead activity causes a gradual stretching of the anteroinferior capsuloligamentous structures leading to mild laxity, instability, and impingement of the shoulder (Sein et al., 2010). A competitive swimmer averages 6-8 workouts per week and trains a majority of the year with few opportunities to take a break from the sport to allow the shoulders to recover from the high demands. Marberry and Schisler (2009) reported that 80% of swimmers complained of shoulder pain sometime during their careers. The percentage of swimmers reporting shoulder pain increases with competition level (47% of national age group swimmers, 66% in senior elite groups, and 73% of US National Swim Team). Additional factors associated with shoulder pain in swimmers include extrinsic factors such as poor swimming technique and intrinsic factors such as scapular dyskinesis (Bak, 2010).

Pain is a complex event with sensory, affective, evaluative, cognitive, and behavioral dimensions (Sim & Waterfield, 1997). High levels of reliability for pain scales depend upon careful client instruction and a standardized procedure because of subjectivity of patient reported pain levels. A visual analog scale (VAS) uses a 10-cm line with verbal descriptors such as 'no pain' and 'worst imaginable pain'. The subject marks a line to indicate pain intensity. Because pain is multidimensional, VAS scores may vary as much as 20% on repeated testing (Williamson & Hoggart, 2005). Furthermore, VAS may not be responsive to different types of pain (Sim & Waterfield, 1997) and a more qualitative measurement tool is warranted.

A number of functional measurement tools for the upper extremity exist. However, these tools are not specific to swimmers. The Kerlan-Jobe Orthopaedic Clinical Overhead Athlete Shoulder and Elbow (KJOC) and the Disabilities of the Arm, Shoulder, and Hand questionnaire (DASH) are both valid and reliable tools for determining function of the upper extremities (Alberta et al., 2010; Gummesson,Ward & Atroshi, 2006; Hsu et al., 2010). According to Domb et al. (2010), the KJOC score is sensitive for detecting subtle changes in performance in the overhead athlete, whereas the DASH has a ceiling effect for this population (Hsu et al., 2010). Although development of the KJOC did include a small group (n=38) of swimmers, the study did not specifically address the validity and reliability of this tool for swimmers.

Pink et al. (2010) first proposed a swimmer's VAS, which provided the coach and athlete with guidelines for management strategies related to shoulder pain, as well as, determining the need for a referral to a health care professional. Pink et al. (2010) subdivided the swimmer's pain scale into four zones that correspond to increasing pain levels, which included the white (VAS= 0 to 3), yellow (VAS= 4 to 5), orange (VAS= 6 to 8), and red (VAS= 9 to 10) zones.

Currently, there are no validated instruments that are designed specifically for measuring pain and shoulder function in swimmers. The purpose of this study was to develop and validate a self-administered questionnaire that measures pain and functional status of the shoulder in swimmers that may alert a coach or swimmer to seek follow up with a healthcare provider.

Methods

Development and Validation of Questionnaire

Investigators developed the Swimmer's Functional Pain Scale (SFPS), which focuses on pain during the swimmer's functional activities (see Figure 1). The original swimmer's pain scale proposed by Pink and investigators (Pink et al., 2010) used a standard 10-cm horizontal line as the visual analog scale (VAS). Development of the SFPS included functional components of pain "zones" as initially proposed by Pink et al. (2010) For instance, "shampoo arm syndrome" corresponded to a pain level of 3. Shampoo arm syndrome (Figure 2) occurs when the athlete has difficulty shampooing his/her hair after

the workout. Shampooing the hair requires the athlete to abduct the shoulder leading to shoulder impingement or shoulder pain. The treatment for a swimmer's reported pain level of 3 included ice, but the athlete could still complete a full workout even though the athlete minimized certain strokes to avoid pain (Pink et al., 2010). Hence, the SFPS reorganized the swimmer's pain scale proposed by Pink et al. (2010) by using questions about functional activity to determine the score instead of using a VAS. An expert panel that included swim coaches, physical therapists, and sports medicine physicians reviewed the SFPS and provided feedback prior to field-testing. The SFPS requires the competitive swimmer to answer a series of yes or no questions (flow chart) regarding his/her levels of pain and soreness. The final score of the SFPS represents a score from 0 to 10, which in turn, falls into one of four zones: white, yellow, orange or red. Each zone represents increasing pain levels similar to the VAS and provides specific treatment protocols as proposed by Pink et al. (2010).

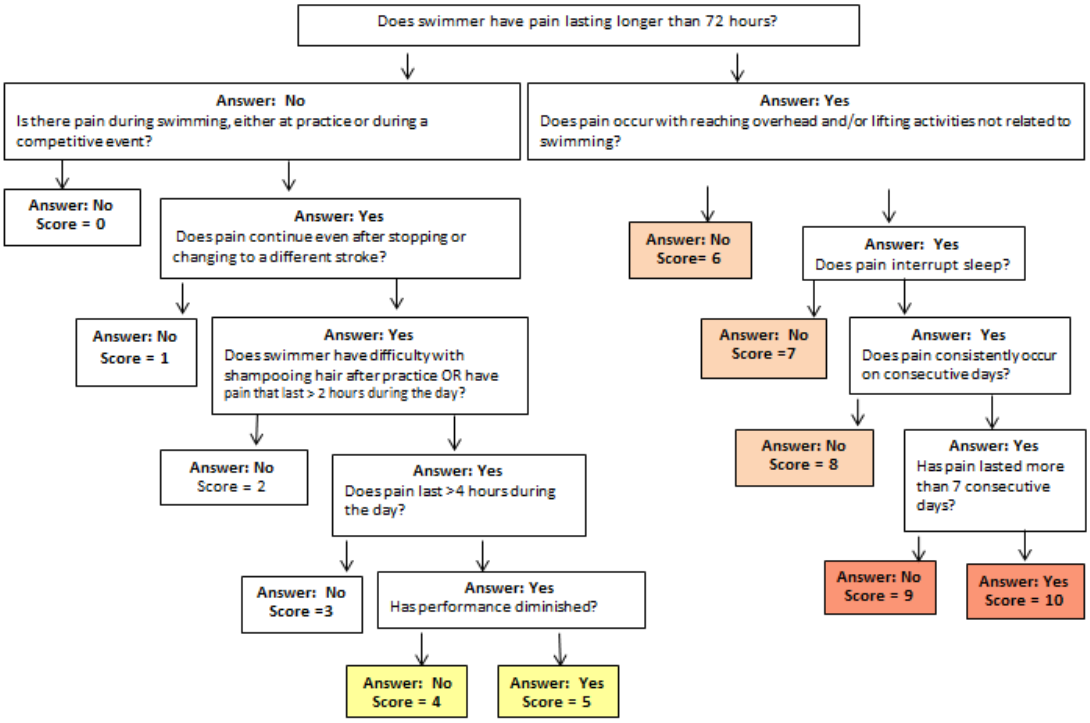

Figure 1. *Selective Functional Movement Scale developed using proposed scale by Pink et al. (2010).*

Figure 2. *Shampoo arm syndrome is characterized by shoulder pain while shoulders are in the abducted position.*

Alberta et al. (2010) developed the KJOC as a way to measure functional status of the upper extremity in the overhead athlete. The KJOC self-administered questionnaire uses ten separate VAS to determine functional status. Although swimmers participated in the validation study with the KJOC, the questionnaire is not specific to swimmers. The cumulative KJOC score ranges from 0 (most severe disability) to 100 (no disability).

Subjects

The study population consisted of USA Swimming age group swimmers (13-18 years of age) and collegiate swimmers (n=58, mean age = 16 ± 2 years; males=28, females= 30). Swimmers were recruited from Arkansas, Washington and Delaware. Inclusion criteria required swimmers to swim a minimum of 4,000 yards/day and be 13 years of age or older. Exclusion criteria consisted of the swimmer's inability to understand the questionnaire. The Institutional Review Board at Arkansas State University (ASU) and the University of Washington approved the study. Athletes selected from Delaware were included in the IRB approved by ASU. All swimmers and parents (if under the age of 18 years) provided consent on the first day of testing.

Procedures

The investigators contacted each swim club's coach to schedule two separate testing dates for pre and post testing. Each subject completed demographic and past medical history information prior to completing the questionnaires. Subjects completed the KJOC and SFPS at the initial meeting and 4-5 weeks after the initial meeting. The subjects and investigators were blinded to the scores at each test date.

Reliability

Evaluation of reliability consisted of a test-retest design in which athletes completed the SFPS and KJOC questionnaire. Wilcoxon's signed rank test for non-parametric data was used to determine whether any systematic differences existed in test-retest scores for the SFPS ($p= 0.214$) and KJOC ($p = 0.267$). Furthermore, to determine internal consistency, Cronbach's alpha (α) was determined between pre and post SFPS and KJOC scores. A value between .70 and .90 was considered reliable (Portney & Watkins, 2009).

Validity

Validity was analyzed using the Spearman's correlation coefficients between SFPS and the KJOC score. The significance level was $p \leq 0.05$. Correlation coefficients used for interpretation were as follows: $r \leq 0.49$ as weak relationship; $0.50 \leq r \leq 0.74$ as moderate relationship and $r \geq 0.75$ as a strong relationship (Portney and Watkins, 2009).

Categorical Variables

The SFPS score represents a number on a VAS between 1 and 10. Each number falls within a training category of white (1-3), yellow (4-5), orange (6-8) or red (9-10). Participants were asked if they were currently swimming without pain (Category 1), swimming with pain (Category 2) or not swimming due to pain (Category 3) on the KJOC. A chi-square analysis measured the association between the SFPS color category and the KJOC category.

Statistical Analysis

The number of swimmers needed for the study was determined to be 57 swimmers using the Wilcoxon signed-rank test for matched pairs. The total sample size was determined using a two-tailed distribution with an effect size of 0.5, α error probability of 0.05, and power at 0.95 (G * Power 3.1.5). All data were analyzed using IBM SPSS version 20 (SPSS, Inc., Chicago, Illinois, USA). Nonparametric statistics were used since the swimmer's functional pain scale was not sufficiently studied to determine homogeneity (Portney and Watkins, 2009) and data were expected to be skewed. Questionnaires with missing scores were not used in results.

Results

Demographics

Swimmers reported a mean of 9.7 ± 2.8 years of competitive swimming experience, 6 ± 2 workouts per week and 41 ± 5 weeks of training per year. Swimmers reported swimming a mean of 6,322 ± 1800 yards per day (range from 1,000 to 10,000 yards per day). The majority of swimmers reported participating in a dryland program (98%). Approximately 25% of swimmers completing the study reported an "unstable" shoulder and 20% reported missing at least one competition during their swimming career due to a shoulder injury.

Reliability

Descriptive data for the SFPS and KJOC is presented in Table 1. The scores for KJOC range from 0 (most severe disability) to 100 (no disability). The scores for SFPS range from 0 (no disability) to 10 (most severe disability). No significant differences were reported for test-retest scores between pre-KJOC and post KJOC scores ($p = .394$) or for pre-SFPS and post SFPS scores ($p = .181$) using the Wilcoxon signed rank test indicating that pre / post scores are similar for both questionnaires. Cronbach α results indicate moderate reliability for test-retest scores for the SFPS (Cronbach $\alpha = .799$) and high reliability for the KJOC (Cronbach $\alpha = 0.957$).

	Pre- Descriptive Data		Post- Descriptive Data	
	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
KJOC*	82 (18)	86.7 (70.5-96.1)	83 (20)	89.85 (73.5-98.5)
SFPS**	1 (2)	0 (0-2)	2 (2)	1 (0-2)

Table 1. Descriptive data for SFPS and KJOC.

Validity

The SFPS showed a moderate relationship to the KJOC using the Spearman's correlation coefficients for both pre ($r = -0.684$) and post ($r = -0.699$) scores. An inverse relationship exists since "no disability" is associated with a score of 0 on the SFPS and a score of 100 on the KJOC.

Categorical Variables

Only two swim locations completed the questionnaire regarding category for the KJOC. A total of 37 swimmers completed the categorical variable questionnaire. Results of the chi-square analysis (see Table 2) indicate a significant association between the categories ($p = 0.00$). However, caution must be used when interpreting these results since a minimum of five respondents in each category was not met. Interestingly, out of the 37 respondents, no one had score in the "yellow" zone. Thirty respondents stated that they were "swimming without pain" and ranked between 1 and 3 on the SFPS or white zone. Swimmers that responded to "swimming with pain" were represented in the white, orange and red zone. Only one swimmer that participated in the study was not currently swimming due to shoulder pain in the "red" zone.

		SFPS White	SFPS Orange	SFPS Red
KJOC Category 1 Swimming without pain	Observed Frequency	30	0	0
	Expected Frequency	26.8	1.6	1.6
KJOC Category 2 Swimming with pain	Observed Frequency	3	2	1
	Expected Frequency	5.4	0.3	0.3
KJOC Category 3 Not swimming	Observed Frequency	0	0	1
		0.9	0.1	0.1
	Expected Frequency			

Table 2. Chi-square analysis of categorical variables in SFPS and KJOC.

Discussion

The incidence of shoulder problems in swimmers range from 40% to as high as 91% (Allegrucci,Whitney & Irrgang, 1994; McMaster & Troup, 1993; Sein et al., 2010). Having a self-reported functional outcome measure is important for evaluating functional limitations and treatment effectiveness. Although many options are available for outcome measures of the shoulder, a specific outcome measure for swimmers is needed. Swim coaches must supervise, instruct and condition their athletes. At the high school and collegiate levels, many programs have athletic trainers or other health care providers available for evaluation and treatment of athletic injuries. However, the majority of club team coaches train swimmers under the age of 18 years. According to Tate et al. (2012), competitive swimmers under the age of 12 years experienced substantial shoulder pain. Therefore, swim coaches must recognize when a swimmer needs to seek the advice of a healthcare provider. The majority of coaches have limited knowledge regarding evaluation and treatment of injuries. The purpose of the SFPS questionnaire is to provide a self-reported measurement tool that provides swimmers and coaches information on which swimmers should seek further evaluation for shoulder pain.

Approximately 25% of swimmers in our study reported an "unstable shoulder". Shoulder joint instability or "glenohumeral instability" is a common shoulder joint pathology and may be classified as traumatic or atraumatic glenohumeral instability (AGI) (Bigliani et al., 1997). In a study by McMaster and Troup (1993), swimmers reported shoulder laxity in 6% of age group (13- and 14-year old) swimmers, 12% in senior development groups (15- and 16-year old), and 15% in elite female swimmers. Bak and Fauno (1997) concluded that shoulder pain in swimmers is primarily coracoacromial impingement with associated increased glenohumeral translation and positive apprehension test (anterior AGI). The

apprehension test (see Figure 3) was more likely to be positive at 135° compared to 90° of shoulder external rotation.

Figure 3. *Apprehension test for glenohumeral instability.*

The SFPS is a self-reported pain scale that is reliable in the tested population of swimmers and is moderately correlated to the KJOC indicating good validity. Although a high correlation was not found between the SFPS and KJOC, the simplicity of this tool could be beneficial by providing clinically relevant information to the swim coach for deciding whether a swimmer should continue swimming or seek the evaluation of a health care provider. The SFPS allows the coach to classify a swimmer into a particular color zone and each color zone has specific recommendations for treatment of shoulder pain. This study focused on whether total scores on the SFPS correlated with the KJOC. The KJOC further categorized swimmers into three categories: playing without pain, playing with pain and not playing. Results supported a trend that the three KJOC categories relate to the "color zones" as proposed by Pink et al. (2010).

While testing the SFPS questionnaire, two swimmers were subsequently referred to a healthcare provider. Both cases provide examples of swimmers in the "Red Zone". Had it not been for the administered SFPS, the swimmer would have continued to swim, further aggravating the injured shoulder. The coach is not expected to evaluate the root cause of the shoulder problem, but is expected to know when referral is appropriate. The SFPS provides a tool for coaches to know when an athlete should be referred to a health care provider for evaluation.

Case 1. A collegiate swimmer reported "swimming with pain" and scored a 9 (red zone) on SFPS and a 29.2 on the KJOC. At this point, the coach would refer the swimmer to a health care provider. For this swimmer, a physical therapist further evaluated the swimmer to determine if a referral would be appropriate. Shoulder pain occurred with: 1) shoulder

flexion and adduction, 2) shoulder abduction and external rotation, and 3) shoulder extension and internal rotation. Additionally, the swimmer was unable to perform the functional push-up test due to shoulder pain (Figure 4). The swimmer was referred to the college's athletic trainer for follow-up and shoulder rehabilitation. The swimmer returned for post-testing 4-weeks later and reported "swimming with pain" and scored a 7 (orange zone) on the SFPS and scored a 39.2 on the KJOC. On follow-up, she reported pain with 1) shoulder flexion and adduction and 2) shoulder extension and internal rotation. She did not report pain with shoulder abduction and external rotation. The swimmer was still unable to perform a push-up in the pain-free range. This swimmer continued to swim and had not returned to pain-free swimming at the 4-week post-test.

Figure 4. *Performing a functional push-up test.*

Case 2. One age group swimmer scored a 9 on the SFPS and 34.1 on the KJOC and was referred to a health care provider. At the 4-week retesting phase, the coach indicated that the swimmer was receiving physical therapy for biceps tendonitis and was not available for follow-up testing because she was not swimming. Two months later, researchers followed up with this swimmer, and the swimmer had returned to pain-free swimming. (The second swimmer was not included in data analysis because she did not complete post-testing.)

After evaluation of the SFPS, we suggest a change in the decision tree. In this study, we did not have swimmers report a pain level of 4 or 5. After review, authors determined that changing the question order is warranted (SFPS Version 2, see Figure 5). We recommend asking "Has performance diminished?" prior to asking if pain "lasts greater than 4 hours during the day". Both of these questions are consistent with the performance levels of the yellow zone proposed by Pink et al. (2010).

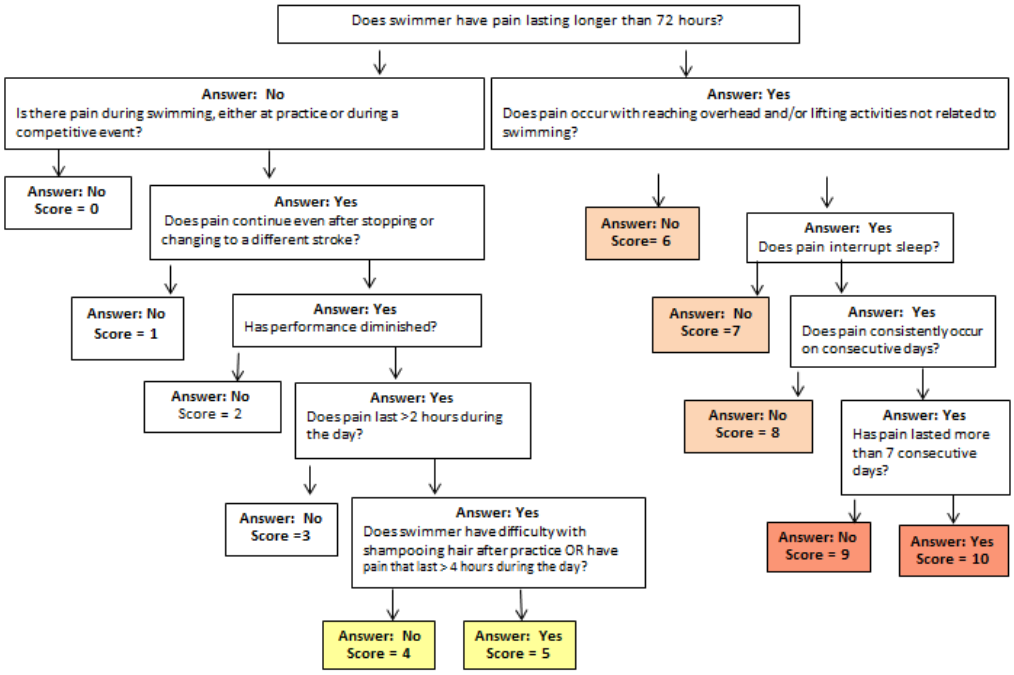

Figure 5. *Updated Swimmer Functional Pain Scale with modifications following testing of original SFPS.*

According to Pink et al. (2010), the orange zone is designated for rehabilitation. Furthermore, recommendations are that if a swimmer scores a 6, the coach should rest the swimmers from workouts at least 3-days. If the swimmer does not improve, a referral is necessary. Swimmers with scores in the red zone should be under the care of a physician, physical therapist or athletic trainer. Results of the SFPS support rehabilitation recommendations as proposed by Pink et al. (2010). Both cases presented above scored in the "red zone" and were referred to a health care provider for follow-up. Although we did not have swimmers score in the "yellow" zone, the investigators agree that swimmers complaining of shoulder pain lasting less than 72 hours should reduce training and ensure proper stroke technique. If the pain last greater than 72 hours, the swimmer should rest if pain is not associated with reaching activities overhead or lifting activities not related to swimming. However, if pain last greater than 72 hours and pain occurs with reaching activities overhead or lifting activities not related to swimming, the swimmer should be referred to a healthcare provider for follow-up. Hence, a referral is warranted when a swimmer scores ≥7 on the SFPS.

One limitation of the study is that most participants reported pain that lasted less than 72 hours. Only four swimmers reported data in the "orange or red zone" during testing. Case studies of two swimmers in the "red zone" support appropriate referrals to a health care provider. Furthermore, the current study did not include swimmers that were surgical candidates or swimmers who wanted to begin swimming following surgery.

Conclusion

The results for the SFPS indicate that the self-reported pain scale is reliable in the tested population of swimmers and is moderately correlated with the KJOC indicating good validity. The simplicity of the SFPS could be beneficial for providing clinically relevant information to swim coaches for deciding whether a swimmer should continue swimming or seek further evaluation from a health care provider. Further research is warranted to address varying reported levels of shoulder problems, surgical candidates and swimmers returning to swim following surgery.

References

1. Alberta, F.G., ElAttrache, N.S., Bissell, S., et al. (2010). The development and validation of a functional assessment tool for the upper extremity in the overhead athlete. *American Journal of Sports Medicine,* 38(5), 903-911.
2. Allegrucci, M., Whitney, S.L., & Irrgang, J.J. (1994). Clinical implications of secondary impingement of the shoulder in freestyle swimmers. *Journal of Orthopaedic and Sports Physical Therapy,* 20(6), 307-318.
3. Bak, K. (2010). The practical management of swimmer's painful shoulder: etiology, diagnosis and treatment. *Clinical Journal of Sports Medicine*, 20(5), 386-390.
4. Bak, K., & Fauno, P. (1997). Clinical findings in competitive swimmers with shoulder pain. *American Journal of Sports Medicine*, 25(2), 254-260.
5. Bigliani, L.U., Codd, T.P., Connor, P.M., et al. (1997). Shoulder motion and laxity in the professional baseball player. *American Journal of Sports Medicine*, 25(5), 609-613.
6. Domb, B.G., Davis, J.T., Alberta, F.G., et al. (2010). Clinical follow-up of professional baseball players undergoing ulnar collateral ligament reconstruction using the new kerlan-jobe orthopaedic clinic overhead athlete shoulder and elbow score (KJOC score). *American Journal of Sports Medicine, 3*8(8), 1558-1563.
7. Gummesson, C., Ward, M.M., & Atroshi, I. (2006). The shortened disabilities of the arm, shoulder and hand questionnaire (quickdash): Validity and reliability based on responses within the full-length dash. *BMC Musculoskeletal Disorders,* 7(44).
8. Hsu, J.E., Nacke, E., Park, M.J., Sennett, B.J., & Huffman, G.R. (2010). The disabilities of the arm, shoulder, and hand questionnaire in intercollegiate athletes: Validity limited by ceiling effect. *Journal of Shoulder and Elbow Surgery,* 19(3), 349-354.
9. Marberry, K. & Schisler, D. (2009). Diving and swimming injuries. In: Buschbacher R, Prahlow N, Save S, eds. *Sports medicine rehabilitation: A sport-specific approach*. New York: Lippincott Williams & Wilkins, 93-108.
10. McMaster, W.C. & Troup, J. (1993). A survey of interfering shoulder pain in united states competitive swimmers. *American Journal of Sports Medicine,* 21(1), 67-70.

11. Pink, M., Edelman, G., Mark, R. & Rodeo, S. (2010). Applied biomechanics of swimming. In: Magee, D., Manske, R., Zachazewski, J., & Quillen, W., eds. *Athletic sport issues in musculoskeletal rehabilitation*. St. Louis, MO: Elsevier: Saunders, 331-349.
12. Portney, L., & Watkins, M. (2009). Surveys and questionnaires. In: Portney, L. & Watkins, M., eds. *Foundations of clinical research*. Upper Saddle River, NJ: Pearson Education, Inc, 325-55.
13. Sein, M.L., Walton, J., Linklater, J., et al. (2010). Shoulder pain in elite swimmers: primarily due to swim-volume-induced supraspinatus tendinopathy. *British Journal of Sports Medicine,* 44(2), 105-113.
14. Sim, J. & Waterfield, J. (1997). Validity, reliability and responsiveness in the assessment of pain. *Physiotherapy Theory and Practice,* 13, 23-37.
15. Tate, A., Turner, G.N., Knab, S.E., Jorgensen, C., Strittmatter, A., & Michener, L.A. (2010). Risk factors associated with shoulder pain and disability across the lifespan of competitive swimmers. *Journal of Athletic Training,* 47(2), 149-158.
16. Williamson, A. & Hoggart, B. (2005). Pain: A review of three commonly used pain rating scales. *Journal of Clinical Nursing,* 14(7), 798-804.