UNIVERSIDADE FEDERAL DE SÃO CARLOS

CENTRO DE CIÊNCIAS BIOLÓGICAS E DA SAÚDE

PROGRAMA DE PÓS-GRADUAÇÃO EM FISIOTERAPIA

TESE DE DOUTORADO

Análise da cadeia cinética em atletas arremessadores com e sem dor no ombro

Lívia Silveira Pogetti

São Carlos

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Tese de doutorado apresentada ao Programa de Pós-Graduação em Fisioterapia da Universidade Federal de São Carlos, como parte dos requisitos para obtenção do título de Doutora em Fisioterapia.

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Resumo

A dor no ombro é bastante prevalente em atletas arremessadores. A alta incidência pode ser resultado de um déficit da ação integrada da cadeia cinética durante o movimento de arremesso. São escassos os estudos que avaliaram os componentes da cadeia cinética em arremessadores com e sem dor no ombro. Estudos desse tipo são importantes para melhor compreensão dos componentes da cadeia cinética nesta população, a fim de obter melhores protocolos de tratamento e avaliação. Os objetivos da tese foram (1) avaliar o desempenho muscular da cadeia cinética de atletas arremessadores com e sem dor no ombro; (2) avaliar a função do ombro, tronco, pelve e membro inferior nesta população; e (3) analisar a correlação entre estas variáveis e o desempenho muscular nos atletas com dor no ombro. Para avaliação do desempenho muscular da cadeia cinética foram utilizados testes de resistência e de contração isométrica voluntária máxima dos músculos flexores, extensores e flexores laterais do tronco, e pico de torque isocinético dos rotadores laterais e mediais de ombro. As contrações isométricas foram avaliadas com dinamômetro manual (Lafayette Instrument Company, Lafayette, IN). O pico de torque dos rotadores laterais e medias de ombro foi avaliado no modo concêntrico à 90º/s, 180º/s e 240º/s no dinamômetro isocinético Multi-Joint System 3 (Biodex Medical System Inc., NY, USA). A função de ombro foi avaliada por meio dos questionários, nível de satisfação do ombro e amplitude de movimento. A função de quadril, tronco e membros inferiores foi avaliada pelo teste de equilíbrio de excursão em estrela (SEBT) modificado e teste de alinhamento pélvico transverso. De modo geral, os resultados mostraram que os atletas arremessadores com dor no ombro apresentaram menor tempo de resistência dos flexores laterais do tronco e equilíbrio, e pior função de ombro em comparação com os atletas sem dor no ombro. No entanto, a dor no ombro parece não afetar o desenvolvimento do pico de torque isocinético e amplitude de movimento do ombro comparado aos atletas sem dor. Além disso, foi observada uma correlação positiva de fraca a moderada entre o pico de torque isocinético de rotadores laterais e mediais de ombro com resistência e força isométrica dos músculos flexores do tronco. O pico de torque não se correlacionou com o alinhamento da pelve. Os resultados gerais suportam a teoria da cadeia cinética baseada na interdependência dos segmentos para gerar e transferir as forças durante o movimento de arremesso. Além de sugerir que exercícios que trabalhem o controle neuromuscular de membro inferior e força isométrica e resistência, particularmente para os músculos flexores e flexores laterais do tronco, devem ser estimulados nos atletas jogando com dor no ombro como parte do plano de reabilitação.

Palavras-chave: isométrico; resistência; core; torque; equilíbrio.

Abstract

Shoulder pain is quite prevalent in throwing athletes. The high incidence may be the result of a deficit of the integrated action of the kinetic chain during the throwing movement. There is lack of studies that have evaluated the components of the kinetic chain in throwers with and without shoulder pain. Researches in this area are important since it could provide knowledge about the kinetic chain components in this population, in order to obtain better treatment and evaluation protocols. In this way, the purposes of the thesis were (1) to evaluate the muscular performance of the kinetic chain of throwing athletes with and without pain in the shoulder; (2) to evaluate the function of the shoulder, trunk, pelvis and lower limb in this population; and (3) to analyze the correlation between these variables and the muscular performance in athletes with shoulder pain. Endurance time test and maximum voluntary isometric contraction were used to evaluate the trunk flexors, extensors and lateral flexors muscles. Isometric contraction was measured by handheld dynamometer (Lafayette Instrument Company, Lafayette, IN). Isokinetic dynamometer Biodex Multi-Joint System 3 (Biodex Medical System Inc., NY, USA) in the concentric mode was used to evaluated peak torque of external and internal rotation of the shoulder at 90º/s, 180º/s and 240º/s. Questionnaires, shoulder satisfaction level and range of motion were used to measure the shoulder function, while the modified star excursion balance test (SEBT) and transverse pelvic alignment test were used to assess the hip, trunk and lower limb function. In general, the results showed that throwing athletes with shoulder pain presented shorter endurance time of the trunk lateral flexors and balance, and worse shoulder function compared to asymptomatic athletes. However, shoulder pain does not seem to affect the development of shoulder isokinetic peak torque and ROM compared to athletes without shoulder pain. Furthermore, the results showed the weak to moderate positive correlations between internal and external rotation of the arm and endurance and isometric strength of the trunk flexors. Peak torque of the shoulder was not correlated to transverse pelvic alignment. Such results support the kinetic chain theory based on the interdependence of segments to generate and transfer of forces during functional movements. In addition to suggesting that exercises that work neuromuscular control of the lower limb and isometric strength and endurance, particularly for the trunk lateral flexor and flexor muscles should be stimulated in throwers with shoulder pain as part of the rehabilitation plan.

Key words: isometric; endurance; core; torque; balance.

Lista de tabelas

Manuscrito I

Manuscrito II

Lista de figuras

Manuscrito I

Manuscrito II

Sumário

CONTEXTUALIZAÇÃO

O arremesso é um gesto esportivo bastante complexo por envolver movimentos de segmentos adjacentes ao complexo escápulo-umeral (Putnam, 1993). Dividido tradicionalmente em 6 fases, preparação (*windup*), passo (*stride*), armação do braço (*arm cocking*), aceleração (*acceleration*), desaceleração (*deceleration*), e finalização (*follow through*), o movimento de arremesso do beisebol é o mais estudado (Chu *et al.*, 2016) e servem como base de conhecimento para os demais esportes *overhead* (Bedi, 2011). Esportes *overhead* são os esportes que exigem movimentos acima da cabeça e envolvem uma ação de alta velocidade para jogar a bola (Cools *et al.*, 2005).

A cadeia cinética é responsável por transmitir forças entre os múltiplos segmentos do corpo durante as fases do arremesso, incluindo o pé, o qual realiza contato com o chão, maximizando a força de reação do solo e criando uma base proximal estável para a mobilidade distal (Sciascia *et al.*, 2012). Assim, a cadeia cinética age de forma sequenciada e coordenada para a ativação, mobilização e estabilização dos segmentos do corpo, colocando o segmento distal em uma posição, velocidade e tempo ótimo para produzir a tarefa desejada (Lintner *et al.*, 2008).

A maior parte da força necessária para propelir a bola é gerada pelo membro inferior e tronco para transmitir ao membro superior através de contrações musculares sequenciadas e coordenadas que caracterizam o mecanismo de ação da cadeia cinética fechada. Subsequentemente essa força é afunilada através do complexo escápulo-umeral e transferida para o braço (Kibler, 1995; Hirashima *et al.*, 2002; Veeger e Van Der Helm, 2007). De fato, Kibler et al. (1996) demonstraram que a região do quadril/tronco contribue com aproximadamente 50% da energia cinética e força utilizadas no movimento de arremesso.

Os músculos do tronco e quadril, coletivamente conhecidos como musculatura do "core" (centro), são responsáveis pela função de estabilização da coluna e da pelve, e ajudam a transferir energia para partes distais do corpo durante as atividades esportivas (Sciascia *et al.*, 2012). Esta estabilidade só é possível devido a sua localização central (Sciascia e Kibler, 2011). Assim, a ótima estabilidade do "core" é garantida pela força e da resistência para proporcionar o funcionamento adequado da cadeia cinética, afim de controlar a posição e o movimento do tronco sobre a pelve e os membros inferiores permite a ótima produção, transferência e controle da força para os segmentos terminais (Kibler *et al.*, 2006; Sciascia *et al.*, 2012).

Além da força e da resistência, o controle neuromuscular é outro aspecto importante para gerar estabilidade do "core" em atividades esportivas (Borghuis *et al.*, 2008). O controle neuromuscular do "core" envolve sua capacidade em responder as perturbações internas e externas exposta pelo esporte, desencadeando respostas sinérgicas em antecipação a mudanças posturais repentinas. Assim, contribui para manutenção e recuperação do equilíbrio postural, permitindo que o corpo permaneça estável mesmo diante de grandes esforços físicos (Borghuis *et al.*, 2008). Um dos poucos estudos que buscou a correlação das disfunções no ombro em atletas *overhead* com a estabilidade do "core", observou que a população com dor no ombro apresentou déficit de equilíbrio no teste de apoio unipodal quando comparados com atletas sem dor no ombro (Radwan *et al.*, 2014). Dessa forma, o controle neuromuscular é um importante componente para o equilíbrio corporal e a sua deficiência pode impactar negativamente no desempenho destes atletas.

No movimento de arremesso, a escápula é o principal elo entre os maiores segmentos corpóreo, como o membro inferior e tronco, os quais são responsáveis pela estabilidade e produção de força, e os menores segmentos localizados no membro superior que produzem mobilidade e aplicam a força sobre a bola (Kibler, Ludewig, *et al.*, 2013). No ombro, a escápula desempenha o papel de base estável para ação dos músculos do manguito rotador durante o movimento do braço no arremesso (Sciascia e Kibler, 2011). Como parte da cadeia cinética, a escápula permite a transferência de energia dos músculos do "core" para o braço. A posição de extrema rotação lateral e abdução do braço facilita essa transferência de energia. No sistema fechado da cadeia cinética, a alteração em uma área pode gerar alterações em todo o sistema (Sciascia *et al.*, 2012). Dessa forma, a alteração na produção de força nos segmentos proximais da cadeia cinética, provoca um aumento de forças imposta sobre os segmentos distais resultando, frequentemente, em sensação de dor ou lesão anatômica (Putnam, 1993; Kibler, 1995). Assim, é importante que todos os elementos da cadeia cinética estejam íntegros e funcionais para que o movimento de arremesso seja efetivo e minimize o risco de dor ou lesão.

Além disso, estudos têm mostrado que a alteração no movimento da escápula pode esta associada ao déficit de rotação medial da glenoumeral (Burkhart *et al.*, 2003; Kibler, Kuhn, *et al.*, 2013; Kibler, Ludewig, *et al.*, 2013; Clarsen *et al.*, 2014). Considerada como componente chave da biomecânica normal e anormal do arremesso, a rotação glenoumeral deve ser analisada devido às adaptações osteomioarticulares, que ocorrem durante a fase de desaceleração do braço. Estas adaptações promovem aumento da rotação lateral e a redução da rotação medial da glenoumeral e podem ser uma das razões da dor no ombro em atletas arremessadores (Almeida *et al.*, 2013).

A dor no ombro é o principal problema entre os atletas arremessadores. Segundo Tullos e King (2000) pelo menos 50% dos jogadores de beisebol já apresentaram dor no ombro. Índices de dor no ombro de 19,6% e 36% foram encontrados nas jogadoras de handebol do time de elite da Noruega (Myklebust *et al.*, 2013) e Irã (Mohseni-Bandpei *et al.*, 2012), respectivamente. Além disso, estudos têm reportado que a incidência de dor aguda ou crônica no ombro está entre 30% e 45% em jogadores de handebol (Pieper, 1998). Considerando a alta incidência de dor no ombro nos esportes *overhead* e a escassez de estudos que tenham avaliado os componentes da cadeia cinética, como o desempenho muscular do tronco, quadril e ombro, em arremessadores com dor no ombro. Nota-se a importância de se realizar estudos que possam permitir melhor entendimento dos componentes da cadeia cinética em atletas arremessadores com e sem dor no ombro a fim de obter melhores protocolos de avaliação e, consequentemente tratamento.

OBJETIVOS DA TESE

Os objetivos da tese foram (1) avaliar o desempenho muscular (tempo de resistência e força isométrica do "core" e torque isocinético dos músculos rotadores laterais e mediais do ombro) dos componentes da cadeia cinética de atletas arremessadores com e sem dor no ombro; (2) avaliar a amplitude de movimento de rotação lateral e medial do ombro e sua capacidade funcional, bem como o desempenho funcional do tronco, pelve e membro inferior nesta população; e (3) analisar a correlação entre estas variáveis e o desempenho muscular nos atletas com dor no ombro.

HIPÓTESES DA TESE

As hipóteses desta tese foram que (1) atletas arremessadores com dor apresentariam pior tempo de resistência e força isométrica do “core” e pico de troque de rotação lateral e medial de ombro; (2) pior amplitude de movimento de rotação lateral e medial do ombro e maior incapacidade funcional de ombro; bem como (3) pior desempenho funcional de pelve, quadril e membro inferior quando comparados com arremessadores sem dor; e (4) haverá uma correlação entre as variáveis de desempenho muscular e funcional dos componentes do “core” e o pico de torque de rotação lateral e medial de ombro.

COMPOSIÇÃO DA TESE

A tese será apresentada no formato de 2 manuscritos.

Manuscrito 1 – Comparou a estabilidade do “core” e o pico de torque isocinético do ombro em atletas arremessadores com e sem dor no ombro. Além disso, o estudo comparou a função do ombro, nível de satisfação com o braço de arremesso e amplitude de movimento de rotação lateral e medial de ombro. Os resultados apresentados contribuem na melhor compreensão da influência da cadeia cinética no sobre o desempenho esportivo destes atletas. Além disso, podem auxiliar no desenvolvimento de protocolos de avaliação e tratamento de lesões no complexo do ombro para atletas arremessadores.

Manuscrito 2 – Analisou a correlação entre a estabilidade do “core” e o pico de torque isocinético de rotadores laterais e mediais de ombro em atletas arremessadores com dor no ombro. Os resultados deste estudo podem auxiliar a compreender a relação da estabilidade do “core” sobre o pico de torque dos músculos rotadores do ombro, assim como na elaboração de protocolos de intervenção de lesões nestes atletas.

Manuscrito I

CORE STABILITY, SHOULDER PEAK TORQUE AND FUNCTION IN THROWING ATHLETES WITH AND WITHOUT SHOULDER PAIN

Pogetti, LS; Nakagawa, TH; Conteçote, GP; Camargo, PR

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ABSTRACT

Background: Shoulder pain in throwing athletes may be linked to core instability.

Purposes: To compare core stability and shoulder isokinetic peak torque in throwing athletes with and without shoulder pain, and to investigate shoulder function in these athletes.

Study Design: Cross-sectional study.

Methods: Thirty healthy and twenty-five throwing athletes with shoulder pain participated in this study. Core stability was evaluated by the modified star excursion balance test (SEBT) and by the endurance time of the trunk flexor, extensor, and lateral flexor muscles. Isokinetic concentric peak torque of internal and external rotation of the shoulder was evaluated at 90º/s, 180º/s and 240º/s. Questionnaires, level of satisfaction with throwing arm and range of motion (ROM) were used to evaluate shoulder function.

Results: There was no significant difference between groups in the endurance time for the trunk flexors (*P*=.85) and extensors (*P*=.95). However, endurance time was shorter for the trunk lateral flexors performed on the ipsilateral (*P*=.004) and contralateral sides (*P*=.04) of the throwing arm in athletes with shoulder pain. No significant difference was found during SEBT for the anterior direction for both limbs (*P*>.05), and also for takeoff limb in the posterolateral direction (*P*= .14). However, athletes with shoulder pain presented decreased reach distance for both limbs in the posteromedial direction (*P*< .05) and for takeoff limb in the posterolateral direction (*P*=.04), and smaller composite score for both limbs (P< .05) during SEBT. No significant differences between groups were found in isokinetic peak torque for external rotation at 90º/s (*P*=.63), 180°/s (*P*=.95) and 240°/s (*P*=.50) as well as for internal rotation at 90º/s (*P* =.78), 180°/s (*P* =.70) and 240°/s (*P* =1.00). Athletes with shoulder pain demonstrated worse function of shoulder and a low level of satisfaction with the throwing arm (*P*=.000). ROM was not different between groups for shoulder external (*P*= .88) and internal rotations (*P*=.21).

Conclusion: Throwing athletes with shoulder pain have poor core stability and shoulder function.

Clinical Relevance: Exercises for the lateral flexors of the trunk should be stimulated in the throwing athletes with shoulder pain as part of the rehabilitation plan.

Key Terms: Endurance, Balance, Torque, Kinetic chain.

INTRODUCTION

The prevalence of shoulder pain is enormous in competitive throwing athletes (Mohseni-Bandpei *et al.*, 2012; Myklebust *et al.*, 2013). The high prevalence of injuries is drawing attention to biomechanical risk factors on stresses and loads at the upper extremity. Following this reasoning, many studies have suggested that the shoulder injury may be linked to core instability due to inefficiency of the neuromuscular system (Kibler *et al.*, 2006; Sciascia *et al.*, 2012; Radwan *et al.*, 2014; Silfies *et al.*, 2015).

Located in the central region of the trunk, the core (Kibler *et al.*, 2006) muscles can contribute to around 55% of the kinetic energy and force to the entire throwing motion (Lintner *et al.*, 2008; Kibler, Ludewig, *et al.*, 2013). According to Kibler (1996), a decrease of 20% of the kinetic energy delivered from the core to the arm requires an increase of 80% in mass or 34% in rotational velocity at the shoulder to deliver the same amount of resultant force to the hand. Consequently, a deficient core seems to increase the risk of injuries in the upper extremity due to overload in the shoulder joint and, negatively affect the athletic performance (Kibler *et al.*, 2006; Sciascia *et al.*, 2012).

Recent studies have investigated the relation between core stability and injuries in the upper limbs of overhead athletes (Garrison *et al.*, 2013; Chaudhari *et al.*, 2014; Endo e Sakamoto, 2014; Harrington *et al.*, 2014; Oliver, 2014; Radwan *et al.*, 2014). However, results are still conflicting. Some investigations have related poor core stability to shoulder injuries and/or pain (Garrison *et al.*, 2013; Chaudhari *et al.*, 2014; Radwan *et al.*, 2014), while others show no differences in core stability between overhead athletes with and without shoulder pain (Endo e Sakamoto, 2014; Harrington *et al.*, 2014). More investigations are warranted to better understand the role of core stability in throwing athletes with and without shoulder pain in order to advance with more focused treatments, evaluation protocols and, consequently, the performance in this population.

The primary purpose of this study was to compare core stability and shoulder isokinetic peak torque in throwing athletes with and without shoulder pain. A secondary objective was to investigate shoulder function in these athletes. It was hypothesized that the throwing athletes with shoulder pain would demonstrate worse core stability, peak torque and shoulder function.

METHODS

Study Design and Participants

This is a cross-sectional study. Using the GPower software 3.1.9.2 the a priori sample size was calculated based on the core endurance time of the trunk flexor muscles from the first 10 individuals of each group (with and without shoulder pain). The trunk flexors endurance time was chosen because these muscles can be highly affected in case of continuous activation and fatigue during the throwing motion (Kibler *et al.*, 2006). Calculations were made using α = 0.05, β = 0.80, a within-group standard deviation of 19.90s, and an expected difference between groups of 19.80s. Based on these criteria, at least 26 individuals per group were required in each group. Fifty-five collegiate throwing athletes (handball, baseball and softball) participated in study and were divided into two groups: athletes with shoulder pain (n=25) and athletes without shoulder pain (n=30). Participants were recruited using flyers posted in university buildings and community public places, social networks, nearby cities and personal contacts of the investigators. The basic descriptive characteristics of the participants are presented in Table 1.

Symptomatic athletes had to present signs of shoulder impingement that was clinically diagnosed as a combination of three or more positive signs of the five following tests: Neer (Neer, 1972), Hawkins-Kennedy (Hawkins e Kennedy, 1980), Jobe (Jobe e Moynes, 1982), painful arc(2010), and resisted shoulder external rotation test (Park *et al.*, 2005). According to the literature, a combination of shoulder tests may provide better diagnostic accuracy to confirm shoulder impingement (Michener *et al.*, 2009). Asymptomatic athletes had to present no history of pain or dysfunction in the shoulder and/or neck. Only the arm used to throw was evaluated. All players had to be training at least three times a week, have at least one year of practicing sports, and to be participating in competitions. Potential participants were excluded if they had of the following: history of surgery and fracture in the upper and lower limbs or trunk; generalized laxity following the criterion of Beighton and Horan (Boyle *et al.*, 2003); positive sign for drop arm test (Lintner *et al.*, 2008); history of pain in the lower limbs and trunk in the last 3 months; positive sign for cervical compression test (Spallek *et al.*, 2007); history of neurological or cardio-respiratory disorders as self-reported. This study was approved by the Ethics Committee of the University **(Anexo I)**. All participants who agreed to participate signed an informed-consent agreement, which was conducted according to the Helsinki Declaration **(Apêndice I)** and followed by a clinical examination questionnaire **(Apêndice II)**.

Shoulder Pain, Function and Level of Satisfaction

The Brazilian Portuguese version of Athletic Shoulder Outcome Rating Scale (ASORS) (Leme *et al.*, 2010) and the Shoulder Pain and Disability Index (SPADI) (Martins *et al.*, 2010) were used to assess shoulder pain and function in all participants. The questionnaires are valid and reliable for assessing shoulder of athletes (Leme *et al.*, 2010) and pain and disability (Martins *et al.*, 2010) in individuals with upper-limb symptoms. The ASORS is divided into three aspects: competitive level, diagnosis and objective (range of motion) and subjective parameters (pain, strength/endurance, stability, strength, and performance). Scores range from 0 to 100, with higher scores indicating a better physical condition (Leme *et al.*, 2010). The SPADI consists of 13 items distributed in the pain domain (five items) and disability domain (eight items), being each item scored in a Numeric Rating Scale ranging from 0 to 10 points. The total score of the questionnaire, as well as the score of each domain separately is converted in percentages ranging from 0 to 100, with the higher scores indicating a worst condition of shoulder dysfunction (Martins *et al.*, 2010).

The level of satisfaction with the shoulder was scored by a Numeric Scale ranging from 0 (not satisfied) to 10 (satisfied) points. All individuals had to answer the level of satisfaction with the shoulder during throwing.

Shoulder Range of Motion

A digital inclinometer (Acumar ™, Lafayette Intrument Company, Lafayette, IN) was used to measure range of motion (ROM) of the shoulder external and internal rotation. Individuals were positioned in supine with the shoulder at 90° of abduction and 90° of elbow flexion (Awan *et al.*, 2002; Thomas *et al.*, 2011). The inclinometer was positioned on the dorsal and palmar surface of the forearm to assess internal and external rotation, respectively (Awan *et al.*, 2002; Thomas *et al.*, 2011). Athletes were asked to perform the maximum range of rotation for the measurement (Awan *et al.*, 2002; Thomas *et al.*, 2011). They were instructed to avoid compensations with the trunk or contralateral limb during the movement. A second examiner helped to stabilize the shoulder during measurement of internal rotation. The averages of two measurements were considered for analysis.

Core Endurance Time

Endurance tests for the trunk flexors and extensors were conducted and measured as described by McGill et al.(1999), while the lateral flexor was modified from the side bridge test. These tests were evaluated and recorded in seconds. Participants performed one practice trial that lasted a few seconds to confirm position and then, one test trial was recorded per randomized positions where the time was measured. The same investigator visually determined the start and end of all tests, while an assistant investigator recorded the test by a video camera. The videos were posteriorly analyzed by the two investigators to confirm the start and end of all tests. A third investigator would be consulted in case of disagreement, however, this was not necessary. All individuals received standardized verbal encouragement to keep the positions during the tests. A minimum of 5 minutes was provided between efforts to facilitate recovery (Mcgill *et al.*, 1999).

The endurance tests for the trunk extensors and lateral flexors required the athletes to be positioned with their pelvis over the edge of the treatment table and their limbs stabilized by two straps (Figures 1A and C) (Mcgill *et al.*, 1999). Before the start, the athletes were instructed to remove their hands of the chair and cross them across their chest. The tests ended when participants were unable to keep in the start position (Mcgill *et al.*, 1999). The lateral flexors endurance test was evaluated on the both sides. The athletes were instructed to keep the horizontal position as long as possible.

The endurance test for the trunk flexors required the athletes to sit on the treatment table and place their upper body against a wedge with an angle of 60°. In this position, the knees and hip were flexed 90°, the arms were crossed across the chest, and toes were placed under two straps (Figure 1B) (Mcgill *et al.*, 1999). Individuals were instructed to keep their body position while the supporting wedge was pulled back 10cm to start the test. The test ended when the upper body fell below the 60° angle.

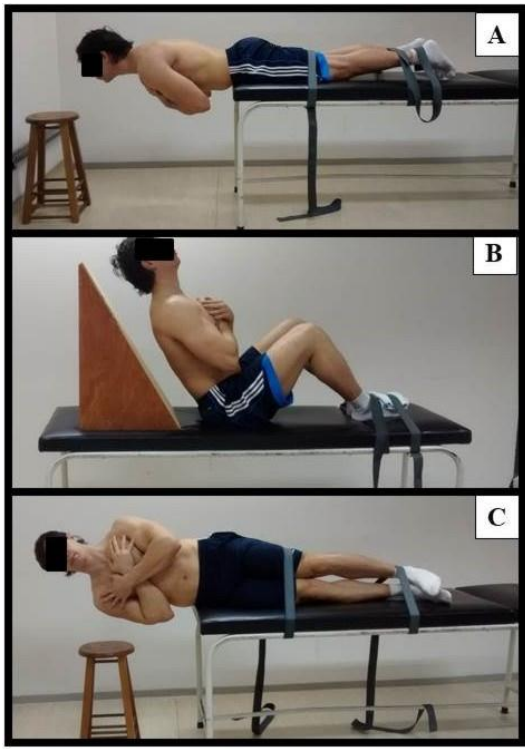

Figure 1. Participant positioned for (A) extensors endurance, (B) flexors endurance and (C) lateral flexors endurance tests.

Prior to the study, 10 participants were tested on 2 occasions, separated by 3 days to establish test-retest reliability of endurance time measurements of the core muscles. The intraclass correlation coefficient (ICC) and standard error of measurement (SEM) were 0.77 and 2.46s for flexion, 0.97 and 4.92s for extension, 0.89 and 4.25s for ipsilateral flexion and 0.83 and 3.13s for contralateral flexion.

Modified Star Excursion Balance Test (SEBT)

The modified SEBT was used to assess neuromuscular control of the trunk and pelvis. This test incorporates a single limb stance and requires the individual to use the nonstance limb to reach maximally to touch a point along the 3 designated lines of the ground: Anterior (ANT), Posteromedial (PM), Posterolateral (PL) (Plisky *et al.*, 2006; Filipa *et al.*, 2010). To assess the reaching directions, 3 tape measures were arranged on the ground: 1 anterior from a center point and 2 aligned at 135° to the anterior in the PM and PL directions

(Figure 2) (Coughlan *et al.*, 2012). Both limbs were tested. The stance limb was defined as the leg ipsilateral to the throwing arm, while the takeoff limb as the leg contralateral to the throwing arm (Wagner *et al.*, 2011; Chu *et al.*, 2016). The order of limbs and directions to be assessed was randomized among individuals.

The test was first demonstrated by the first author before the participant completed 4 practice trials in each direction on each limb (Robinson e Grubble, 2008). After the practice trials were completed, each participant was given a 2-minute rest period and, then conducted 3 test trials in each direction (Coughlan *et al.*, 2012). The maximal reach distance was measured by foot touch in the tape measure (Plisky *et al.*, 2006). A trial was classified as invalid if the participant removed his hands from his hips, did not return to the starting position, applied sufficient weight through the reach foot so as to gain an increase in reach distance, placed the reach foot on the ground on either side of the line, raised or moved the stance foot during the test. If an invalid trial occurred, the participant repeated the trial (Coughlan *et al.*, 2012).

Figure 2. Modified Star Excursion Balance Test with reaching directions named (A) anterior, (B) posteromedial and (C) posterolateral in orientation to the stance limb.

Prior to initiation of the study, 10 participants were tested on 2 occasions, separated by 3 days to establish test-retest reliability of the modified SEBT measurements. The ICC and SEM for the stance limb was 0.96 and 4.22% for ANT, 0.96 and 4.49% for PM, 0.97 and 4.10% for PL directions. For the takeoff limb, ICC and SEM were 0.97 and 3.60% for ANT, 0.97 and 3.85% for PM, 0.92 and 7.05% for PL directions.

Isokinetic Shoulder Peak Torque

This evaluation was carried out using the isokinetic dynamometer Biodex Multi-Joint System 3 (Biodex Medical System Inc., NY, USA) in the concentric mode and recorded at 100 Hz. The dynamometer calibration was checked before every evaluation session.

This test was conducted and measured as described by Zanca et al.(2011). The participants were evaluated in the seated position while secured with pelvic and diagonal straps for trunk stabilization. The throwing arm was positioned at 90◦ of shoulder abduction and 90◦ of elbow flexion (Figure 3). The olecranon was aligned with the dynamometer's mechanical axis of rotation. Gravity correction was performed with the arm relaxed at 90◦ of shoulder abduction, in neutral rotation with the forearm parallel to the ground (Zanca, Oliveira, Saccol e Mattiello-Rosa, 2011).

Peak torque was measured during shoulder internal and external rotation through a ROM of 90◦, from neutral rotation to 90◦ of external rotation, at three angular velocities in the following order: 90◦/s, 180◦/s and 240◦/s. For familiarization, the participants performed 3 submaximal repetitions at each velocity. After 1 min of rest, five maximal reciprocal repetitions were performed, and the participants received standardized verbal encouragement to develop maximal strength in all contractions. Two minutes of rest were allowed between each velocity (Zanca, Oliveira, Saccol e Mattiello-Rosa, 2011). The concentric tests were carried out in ascending order of velocity (Dvir, 1995).

Figure 3. Participant positioned for isokinetic assessment, with the arm at the end range of motion (90º of shoulder external rotation).

Eight participants were tested on 2 occasions, separated by 3 days to establish test-retest reliability of isokinetic shoulder peak torque measurements prior to the study. The ICC and SEM were 0.88 and 3.54Nm for external rotators and 0.86 and 4.40Nm for internal rotators at 90°/s; 0.89 and 3.26Nm for external rotators and 0.93 and 0.71Nm for internal rotators at 180º/s; 0.91 and 3.01Nm for external rotators and 0.93 and 5.77Nm for the internal rotators at 240°/s.

Data Analysis

To express reaching distance as a percentage of limb length, the normalized value was calculated as reaching distance divided by limb length then multiplied by 100 (Plisky *et al.*, 2006). Limb length was measured from the anterior superior iliac spine to the center of the medial malleolus with the individual in supine. Composite reaching distance was the sum of the 3 reaching directions divided by 3 times limb length, then multiplied by 100 (Plisky *et al.*, 2006).

Data from the isokinetic tests were exported and processed using MatLab® (version 2008, Math Works Inc., Natick, USA) to extract torque during internal and external rotation. Although the accuracy for velocity is given as 1◦/s, we used an error of 10% for the periods of plateau and the preset velocity. In the cases that the preset velocity was not reached, the subject was excluded of statistical analysis.

Statistical Analysis

Mean and standard deviation were calculated for all data (demographic, ROM, pain scores and satisfaction level, SEBT, isokinetic shoulder peak torque and core endurance time). Statistical analysis was performed for all individuals with a complete data set in SPSS Version 17.0 (SPSS Inc, Chicago, IL). Shapiro-Wilk test was used to verify normality of the data. Student t test was performed to compare ROM (Internal rotation), SEBT (PL directions for takeoff limb), isokinetic shoulder peak torque (internal rotation at 90°/s and 240°/s), core endurance time (extension and lateral flexion test performed on the contralateral side of the throwing arm) between groups with and without shoulder pain. Mann-Whitney test was used to compare age, body mass, height, ROM (external rotation), pain scores and function scores (ASORS and SPADI), satisfaction level, SEBT (ANT and PM directions and composite reach distance for both limbs, and PL direction for stance limb), isokinetic shoulder peak torque (external rotation at 90°/s, 180°/s and 240°/s, and internal rotation at 180°/s) and core endurance time (flexion and lateral flexion test performed on the ipsilateral side of the throwing arm). Mean difference (MD) and 95% Confidence Interval (CI) was calculated for variables with normal distribution, while the CI for the variables without normal distribution was calculated using the Hodges-Lehmann (HL) estimation. The level of significance was set at .05 for all statistical analyses.

Effect sizes for all variables were calculated using the Cohen d coefficient.(Cohen, 1988) An effect size greater than 0.8 was considered large, of approximately 0.5 moderate, and less than 0.2 small.(Cohen, 1988)

RESULTS

Shoulder Pain, Function Evaluation, Satisfaction Level and Range of Motion

The groups showed different characteristics in relation to shoulder pain, function scores and satisfaction level in the baseline demographics (Table 1). Athletes with shoulder pain demonstrated a higher scores for the questionnaires ASORS (HL, 20.00; 95% CI, 12 – 28) and SPADI (HL,-18.845; 95% CI, -28.47 – 5.38), and a low level of satisfaction with the throwing arm (HL, 2.00; 95% CI, 1.00 – 2.50) when compared to athletes without shoulder pain. ROM was not different between groups for shoulder external (HL, .75º; 95% CI, -11.00º – 10.50º) and internal (MD, 3.78º; 95% CI, -2.20º – 9.76º).

TABLE 1
Demographic characteristics of the athletes[a]

	Without shoulder pain (n=30)	With shoulder pain (n=25)	*P*
Age, y	21.20 ± 3.12	22.04 ± 3.17	.61
Sex	24 man	19 man	-
Body Mass, Kg	75.74 ± 15.46	75.55 ± 11.87	.79
Height, cm	168.23 ± 8.34	174.68 ± 9.14	.65
Modalities	2 baseball, 2 softball, 26 handball	2 baseball, 2 softball, 21 handball	-
Practice time, y	6.27 ± 3.79	6.60 ± 3.42	.97
Level of satisfaction with throwing arm (0-10)	8.27 ± 1.38	6.62 ± 1.41	.001[b]
Range of Motion, deg			
External Rotation	103.60 ± 15.15	102.96 ± 18.50	.68
Internal Rotation	53.70 ± 12.17	49.92 ± 9.42	.30
ASORS (0-100)	94.60 ± 8.63	73.88 ± 16.95	.001[b]
SPADI, %	0.90 ± 1.90	20.00 ± 17.00	.001[b]

[a]Data are reported as mean ± SD. ASORS, Athletic Shoulder Outcome Rating Scale; SPADI, Shoulder Pain and Disability Index.
[b]$P < .05$ (Mann-Whitney tests)

Core Endurance Time

There was no significant difference between groups in the endurance time for the trunk flexors (HL, 1.00s; 95% CI -6.00s – 9.00s) and extensors (MD, .50s; 95% CI, -15.29s – 16.29s). Endurance time was shorter for the trunk lateral flexors performed on the ipsilateral (HL, 11.00s; 95% CI, 4.00s – 19.00s) and contralateral sides (MD, 9.98s; 95% CI, .56 s – 19.42s) sides in athletes with shoulder pain (Table 2).

TABLE 2

Core endurance time (s) data of athletes in each position

	Without shoulder pain (n=30)	With shoulder Pain (n=25)	*P*	Effect Size, Cohen d
Flexors	28.00 ± 26.94	22.56 ±19.27	.85	.23
Extensors	56.90 ±28.63	56.40 ± 29.62	.95	.02
Lateral flexors				
Ipsilateral	44.33± 17.25	31.96 ± 14.81	.004 [b]	.76
Contralateral	44.90 ± 19.93	34.92 ±13.70	.04 [b]	.57

[a]Data are reported as mean ± SD.
[b]*P*<.05 (Student t), when both groups were compared.

Modified SEBT

For the ANT direction, no significant difference between groups was found for the stance (HL, 6.74cm; 95% CI, -.40 cm – 13.73 cm) and takeoff (HL, 5.43cm; 95% CI, -1.54cm – 11.96 cm) limbs. No significant difference also was found reach distance for takeoff limb in the PL (MD, 7.88cm; 95% CI, -.19cm – 15.94cm). However, athletes with shoulder pain presented decreased reach distance for stance limb in the PM (HL, 10.39cm; 95% CI, 1.77cm – 18.79cm) and PL (HL, 10.57cm; 95% CI, 3.19cm – 17.82cm) directions and for takeoff limb in the PM (HL, 9.02cm; 95% CI, 2.69cm – 15.64cm) direction. In addition, athletes with shoulder pain also showed decreased composite reaching distance for the takeoff and stance limbs (HL, 22.14%; 95% CI, 4.71% – 37.26% and HL, 25.42%; 95% CI, 7.71% – 43.99%, respectively, Table 3).

TABLE 3

Modified Star Excursion Balance Test normalized data of the athletes[a]

	Without shoulder pain (n=30)	With shoulder pain (n=25)	*P*	Effect Size, Cohen d
Takeoff limb (%)				
ANT	78.0 ± 13.0	74.0 ± 16.0	.26	.27
PM	116.0 ± 11.4	105.0 ± 16.0	.02[b]	.79
PL	110.0 ± 15.7	103.0 ± 14.0	.06	.48
Composite	304.0 ± 30.6	281.0 ± 31.0	.03[b]	.75
Stance limb (%)				
ANT	77.0 ± 13.0	71.3 ± 14.9	.17	.41
PM	116.0 ± 12.0	104.0 ± 18.0	.008[c]	.78
PL	111.0 ± 15.0	101.0 ± 14.0	.01[c]	.69
Composite	303.0 ± 33.0	276.0 ± 36.0	.005[c]	.78

[a]Data are reported as mean ± SD; ANT, anterior; PM, posteromedial; PL, posterolateral.
[b]$P < .05$ (Mann-Whitney tests), when both groups were compared.
[c]$P<.05$ (Student t), when both groups were compared.

Isokinetic Shoulder Peak Torque

All participants reached the preset velocities in the five repetitions during the concentric test at 90◦/s and 180º/s. However, four participants without shoulder pain and one participant with shoulder pain did not reach the isokinetic phase in the concentric tests at 240◦/s, particularly during external rotation. Thus, five participants were excluded from this analysis.

No significant differences between groups were found in isokinetic peak torque for external rotation at 90º/s (HL, -.01Nm/kg·m; 95% CI -.07Nm/kg·m – .05Nm/kg·m), 180°/s (HL, -.02Nm/kg·m; 95% CI -.07Nm/kg·m – .05Nm/kg·m) and 240°/s (HL, .02Nm/kg·m; 95% CI -.04Nm/kg·m – .10Nm/kg·m) as well as for internal rotation at 90º/s (MD, .0002 Nm/kg·m; 95% CI, -.08Nm/kg·m – .08Nm/kg·m), 180°/s (HL, -.04Nm/kg·m; 95% CI -

.11Nm/kg·m – .04Nm/kg·m) and 240°/s (MD, .0002Nm/kg·m; 95% CI, -.08Nm/kg·m – .08Nm/kg·m) (Table 4).

TABLE 4

Isokinetic shoulder peak torque (Nm/kg·m) data of athletes in each velocity[a]

	Without shoulder pain (n=26)	With shoulder pain (n=24)	*P*	Effect Size, Cohen d
90º/s				
External rotation	0.48 ± 0.15	0.45 ± 0.09	.63	.24
Internal rotation	0.54 ± 0.13	0.55 ± 0.12	.78	.08
180º/s				
External rotation	0.47 ± 0.19	0.45 ± 0.10	.95	.13
Internal rotation	0.53 ± 0.15	0.55 ± 0.11	.70	.15
240º/s				
External rotation	0.47 ± 0.22	0.41 ± 0.10	.50	.35
Internal rotation	0.53 ± 0.16	0.53 ± 0.11	.99	.00

[a]Data are reported as mean ± SD.

DISCUSSION

The main findings of the current study suggest that throwing athletes with shoulder pain have decreased core stability and worse shoulder function compared to asymptomatic athletes. However, shoulder pain does not seem to affect the development of shoulder isokinetic peak torque and ROM.

Core Stability

Strength, endurance and, sensory-motor control are important to provide core stability during dynamic activities (Akuthota *et al.*, 2008). This study demonstrated bilateral decreased endurance time of the lateral flexors of the trunk in athletes with shoulder pain. However, there was no significant difference for the trunk extensor and flexor endurance tests between groups.

An important lateral flexor of the trunk is the latissimus dorsi. There is a hypothesis that this muscle acts as a transmitter of the force gluteus maximus muscle to the upper limbs through myofascial connections (Carvalhais *et al.*, 2013). According to Kaur et al.(2014), the myofascial connection between the hip muscles and lateral flexors of the trunk increases the activation of the anterior serratus. Thus, weakness of the trunk muscles may affect the activation of the serratus anterior, resulting in decreased scapular upward rotation and posterior tilt that may contribute to development of pain and shoulder injury (Ludewig *et al.*, 1996). As such, the interconnections between the lower extremity and upper limbs through the lateral flexors of the trunk form the basis for the kinetic chain theory, and suggest that poor core stability might be associated with shoulder pain in throwing athletes.

The literature shows conflicting results regarding the test of endurance of the lateral flexors of the trunk in overhead athletes with injuries in the upper extremity (Tate *et al.*, 2012; Endo e Sakamoto, 2014; Harrington *et al.*, 2014). A possible reason for these conflicting results may be differences in the test position. According to Tate et al.(2012), the side bridge position requires an optimal glenohumeral and scapular control. This position could initiate the development of pain in the athlete's shoulder that would result in test termination, and could be mistakenly understood as fatigue of the trunk musculature. In the current study, positions that primarily assess trunk muscles capacity were chosen in order to minimize the stresses and strains in the shoulder joint complex (Mcgill *et al.*, 1999).

The throwing movement requires an important trunk rotation. Previous studies have shown that improper sequence of the trunk and pelvis rotation required a greater shoulder proximal force to reach high velocities and great muscular strength predisposing the shoulder to injury (Hirashima *et al.*, 2002; Wagner *et al.*, 2011; Aragon *et al.*, 2012; Oyama *et al.*, 2014). Besides being lateral flexors of the trunk, the latissimus dorsi and external oblique muscles also have the function to control excessive anterior pelvic tilt and also acting eccentrically in the lumbar rotation during the overhead activities (Akuthota e Nadler, 2004; Leetun *et al.*, 2004). Therefore, we can hypothesize that the athletes with shoulder pain in the present study possibly perform poor trunk and pelvic rotation during the throwing, overloading the shoulder joint. However, more studies are necessary to elucidate this speculation.

Our results highlight the importance of the lateral flexors of the trunk during the throwing. Studies with baseball players have demonstrated that the rectus abdominis is mostly activated just before the point of ball release (Hirashima *et al.*, 2002), while that the paraspinal contralateral to the throwing arm was more active during the cocking phase (Watkins *et al.*, 1989). On the other hand, there was muscle activation of the trunk lateral flexors in all levels of pitching (Hirashima *et al.*, 2002). These muscles were considered to be very effective for the generation of high force and energy in the trunk for the throwing movement (Hirashima *et al.*, 2002). Therefore, endurance deficit of the lateral flexors of the trunk seems to highly increase the risk of shoulder pain in throwing athletes.

The balance is another integral component of core stability (Borghuis *et al.*, 2011). In this investigation, athletes with shoulder pain demonstrated poor dynamic balance in both stance and takeoff limbs. Previous studies have shown that PL and PM SEBT reach scores were positively correlated with strength of hip muscles in lacrosse and soccer athletes(Ambegaonkar *et al.*, 2014) and non-athletes (Kang *et al.*, 2015; Wilson *et al.*, 2017), suggesting that individuals with stronger hip musculature may be able to reach further backwards and laterally without losing balance. It is important to highlight that for a good performance of the SEBT, pelvic stabilization is required.

The gluteus medius is one of the main pelvic stabilizers, and the activation of this muscle was recently shown to be positively correlated with activation of the scapulothoracic muscles in young baseball pitchers (Oliver *et al.*, 2015). In fact, alterations in activity of the scapulothoracic muscles were already identified in individuals with shoulder pain (Phadke *et al.*, 2009). In addition, Radwan et al.(2014) have observed that overhead athletes with shoulder dysfunction showed poor performance of the single limb balance test. Although the hip muscles were not assessed in the current study, it is possible that the throwing athletes with shoulder pain had alterations in the gluteus medius.

In contrast to PM and PL SEBT directions, the ANT reach score was not different between groups. According to Coughlan et al.(2012), individuals receive visual feedback from the reach limb during the ANT reach direction as they move and can observe the scored reach distance on each trial (Coughlan *et al.*, 2012). In the PM and PL directions, visual awareness is reduced. Therefore, the inability of the individuals to see their scores places an increased demand on feedforward controls, meaning that individuals should have a good anticipatory control during the test. In addition, the ankle dorsiflexion has been reported to be the best single predictor in the ANT reaching (Kang *et al.*, 2015), thus it doesn't seem to be closely related to the throwing movement or shoulder function, explaining the lack of difference between groups.

The relationship between shoulder dysfunction and core stability are not completely understood. However, there is a theory based upon the hypothesis of deficient core neuromuscular control. Failure to appropriately and timely activate the core muscles may cause spinal instability (Borghuis *et al.*, 2011) and overload the shoulder complex during the overhead activity (Kibler, 1998). This suggests that faulty movement in the core can lead to trauma to the joint and cause increased risk for shoulder dysfunction and pain.

Shoulder

In this investigation, no significant differences were found in isokinetic concentric peak torque for external and internal rotation of the shoulder between groups. This finding refutes the hypothesis that throwing athletes with shoulder pain would demonstrate worse peak torque compared to asymptomatic ones. Similarly, Zanca et al.(2011) have reported that handball players with shoulder pain did not show reduced concentric peak torque of internal and external rotation. A possible reason for the lack of significance in shoulder peak torque could be the position used to assess the peak torque. The seated position cancels the influence of the kinetic chain on the sequential force development from the hip and trunk. Another possibility is that the athletes with shoulder pain were regularly engaged to their regular routine of sports training. Although the ASORS and SPADI scores, and level of satisfaction with the throwing arm were significantly lower in the symptomatic athletes, the level of shoulder pain and function possibly does not affect the ability to develop torque and reach velocities during the isokinetic evaluations. It is important to highlight that the velocities in which the athletes were tested in this study are lower than when they actually are playing (Wilk *et al.*, 2009; Almeida *et al.*, 2013). Therefore, the lower velocities may not be sensitive enough to detect a difference in torque.

Also, the ROM of the shoulder external and internal rotation was not different between groups. Although these results suggest that shoulder ROM maybe not be associated with shoulder pain in these individuals, more investigations are warranted to evaluate this relationship.

Limitations

The current study has some limitations. Shoulder torque was measured in the seated position canceling the effect of the kinetic chain. In addition to the low velocities used as compared to what is really developed during the throwing. Future studies should evaluate the kinetic chain in a simulated game. Assessment of shoulder stability and proprioception using a functional testing should be included in further investigations.

CONCLUSION

This study shows that throwing athletes with shoulder pain have poor core stability and shoulder function as compared to asymptomatic athletes. Shoulder pain does not seem to affect the development of the shoulder isokinetic peak torque and ROM. These results suggest that exercises for the lateral flexors of the trunk, particularly those that emphasize isometric or eccentric trunk twists, should be stimulated in the throwing athletes with shoulder pain as part of the rehabilitation plan.

Manuscrito II

CORE STABILITY IS ASSOCIATED WITH ISOKINETIC PEAK TORQUE OF THE SHOULDER IN THROWERS WITH SHOULDER PAIN

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Abstract

Context: Alterations in core stability have been associated to shoulder pain in throwers. It is still not known if core stability is related to the ability to produce torque to internally and externally rotate the arm in overhead athletes with shoulder pain.

Objective: To verify if there was relationship between core stability and concentric peak torque during internal and external rotation of the arm in throwers with shoulder pain.

Design: Cross-sectional study

Setting: Research laboratory

Patients or Other Participants: Twenty-five collegiate throwers with shoulder pain.

Intervention(s): The athletes performed endurance and isometric strength tests of the trunk flexor, extensor, and lateral flexor muscles, and a pelvic alignment test with unilateral knee extension to evaluate the core stability. Isokinetic concentric peak torque of internal and external rotation of the shoulder of the dominant (throwing) arm was performed at 90º/s, 180º/s and 240º/s.

Main Outcome Measure(s): Core endurance time, isometric strength, lumbopelvic control, and isokinetic concentric peak torque of internal and external rotation of the shoulder.

Results: There was weak to moderate positive correlations between internal and external rotation of the arm ($P<.05$) and both endurance and strength isometric of the trunk flexors and trunk ipsilateral flexors of the dominant arm ($P<.05$). Peak torque of the shoulder was not correlated to any outcome of the trunk contralateral flexors of the dominant arm, trunk extensors and transverse plane pelvic alignment ($P>.05$).

Conclusion: Decreased strength and endurance of the trunk flexors is associated with lower capacity to generate shoulder rotation torque in throwers with shoulder pain.

Key words: endurance, strength, trunk, pelvis

INTRODUCTION

Overhead throwing is characterized by sequential motions of the segments, progressing from the most proximal segment to the most distal segment (Putnam, 1993; Sciascia e Cromwell, 2012). Proper muscle activation helps to generate strength in the core muscles that are responsible to transfer the strength to the terminal links of the shoulder, elbow, and hand (Sciascia e Cromwell, 2012).

Core muscles generate 50% to 55% of the total strength and kinetic energy, and provide a stable base for arm motion in the throwing movement (Burkhart *et al.*, 2003; Kibler *et al.*, 2006). In a theoretical framework, any breakdown of the kinetic chain seems to increase the risk of pain or injuries in the shoulder and elbow joints and may adversely affect the athletic performance (Burkhart *et al.*, 2003; Kibler *et al.*, 2006; Sciascia *et al.*, 2012; Kibler, Wilkes, *et al.*, 2013). If the core delivers 20% less kinetic energy to the arm, there may be an increase of 80% in mass or 34% in rotational velocity at the shoulder to deliver the same amount of resultant force to the hand (Kibler, 1996; Kibler *et al.*, 2006).

Shoulder pain is highly prevalent in overhead athletes (Mohseni-Bandpei *et al.*, 2012; Myklebust *et al.*, 2013), and alterations in core stability have already been associated to shoulder pain in these athletes (Garrison *et al.*, 2013; Chaudhari *et al.*, 2014; Radwan *et al.*, 2014). However, it is still not known if core stability is related to the ability to produce torque to internally and externally rotate the arm in overhead athletes with shoulder pain.

This study aimed to verify if there was relationship between core stability and concentric peak torque during internal and external rotation of the arm in throwing athletes with shoulder pain. It was hypothesized that production of torque during internal and external rotation of the throwing arm would be positively correlated to strength and endurance of the core muscles and transverse pelvic alignment.

METHODS

Study Design and Participants

This cross-sectional study took place in a research laboratory. Using the GPower software 3.1.9.2 a priori sample size was calculated based on the maximal voluntary isometric contraction (MVIC) of the trunk flexor muscles and isokinetic peak torque of the shoulder external rotation at 240º/s of the first 10 individuals with shoulder pain. The MVIC of the trunk flexors was chosen because fatigue of these muscles seems to affect the sporting performance (Kibler *et al.*, 2006). Calculations were made using $\alpha = 0.05$, $\beta = 0.80$, r=0.55. Based on these criteria, at least 24 individuals were required. Twenty-five collegiate throwers with shoulder pain participated in the study (Table 1). All participants had to present of signs of shoulder impingement on the arm used to throw with positive results of 3 of 5 tests: Neer (Neer, 1972), Hawkins-Kennedy (Hawkins e Kennedy, 1980), Jobe (Jobe e Moynes, 1982), painful arc (Hung *et al.*, 2010), and resisted shoulder external rotation test (Park *et al.*, 2005). Additional criterion for participant selection included training at least three times a week, have at least one year of practicing the overhead sport, and to be participating in competitions. Participants who had history of surgery and fracture in the upper and lower limbs or trunk; generalized laxity (Boyle *et al.*, 2003); positive sign for drop arm test (Lintner *et al.*, 2008); pain in the lower limbs and trunk in the last 3 months; positive sign for cervical compression test; or neurological or cardio-respiratory disorders were excluded. Ethical approval was granted by the Ethics Committee of the University **(Anexo 1)**. All participants were given information about the study, and signed the informed consent prior to participation **(Apêndice I)**, as well as followed by a clinical examination questionnaire **(Apêndice II)**.

Table 1. Demographic characteristics of the athletes

	Athletes (n=25)
Age, y	22.04 ± 3.17
Sex	6 woman and 19 man
Body Mass, Kg	75.55 ± 11.87
Height, cm	174.68 ± 9.14
Modalities	2 baseball, 2 softball, 21 handball
Practice time, y	6.60 ± 3.42

Data are reported as mean ± SD

Core Endurance Time

For testing endurance of the trunk flexors and extensors muscles, tests were measured using the method described by McGill et al.(1999). The modified position of the trunk extensor endurance test (sidelying position) was used to evaluate endurance of the lateral trunk flexors muscles. The order of testing was randomized and the tests were recorded in seconds. Prior to performance of each test, participants were allowed to perform one practice trial that lasted a few seconds to holding the trunk position aligned confirm position. Afterwards, one valid trial was video recorded. The videos were posteriorly analyzed to confirm the starting and end positions of all tests. All individuals were encouraged to hold the test position until fatigue. Tests were conducted with at least 5-minutes rest between tests (Mcgill *et al.*, 1999).

For testing the endurance of the trunk extensors and lateral flexors, athletes were positioned with their pelvis over the edge of the plinth and their limbs fixed to the plinth by two straps (Figures 1A e C – Manuscript 1). Athletes were asked to cross their arms over the chest, and then to lift the upper body and maintain a horizontal position for as long as possible. Tests were terminated if they could not maintain the position (Mcgill *et al.*, 1999).

For the lateral trunk flexors endurance test, it was evaluated the ipsilateral and contralateral sides to the throwing arm.

The starting position for the trunk flexor endurance test involved positioning the the athletes sitting on a plinth with their back resting body against a wedge that maintained 60° of flexion from the horizontal. Knees and hip were flexed 90°, the arms were crossed over the chest, and feet secured under two straps (Figure 1B – Manuscript 1) (Mcgill *et al.*, 1999). Individuals were instructed to keep their body position while the supporting wedge was pulled 10cm to start the test. The test was terminated when the upper body fell below the 60° angle.

Test-retest reliability (3 days apart) for the endurance tests was performed on 10 participants prior to the study using the same methods described. The intraclass correlation coefficient (ICC) values ranged from 0.77 to 0.97 for all variables. Standard error of measurement (SEM) values ranged from 2.46 to 4.92s.

Trunk Muscle Maximal Voluntary Isometric Contraction (MVIC)

The handheld dynamometer (Lafayette Instrument Company, Lafayette, IN) was used to measure strength (in Newtons) during MVIC of the extensors, flexors, and lateral flexors of the trunk. Participants performed 1 submaximal practice trial prior for each muscle group before data collection. Then, three trials of 5s each were recorded with a 30-second rest between trials (Nakagawa *et al.*, 2012). If the individuals were unable to perform 3 trials with a variability of less than 10%, another trial was performed (Nakagawa *et al.*, 2012). The order of the muscle groups to be tested was randomized. All individuals received a standardized verbal encouragement given by the same examiner throughout the testing.

To measure MVIC of the trunk extensors, individuals were positioned in prone with their hand crossed behind the neck. The handheld dynamometer was positioned over the spinous process of T6, under an adjustable nylon strap (Figure 2A) (Nakagawa *et al.*, 2012).

For the trunk flexors, individuals were positioned in supine with their hand crossed behind the neck. The handheld dynamometer was positioned over the sternum bone, under an adjustable nylon strap (Figure 2B) (Nakagawa *et al.*, 2012).

For the lateral trunk flexors, individuals were positioned sidelying with their hand crossed across the chest. The handheld dynamometer was positioned 6 cm below the armpit line, under an adjustable nylon strap (Figure 2C). For this test, the participants were instructed not to use the shoulder, elbow and scapula to raise the trunk of the plinth. The ipsilateral and contralateral sides of the throwing arm were evaluated.

For all measurements, the nylon strap was secured around the plinth and resisted the motion. In addition, a second strap was positioned secured firmly around the distal thigh and the plinth, which was used to stabilize lower limb during the test. Data from the MVIC tests were normalized dividing the values by the body mass of each participant.

Test-retest reliability (3 days apart) for MVIC of the trunk muscles measurements was performed on 10 participants prior to the study using the same methods described. The ICC values ranged from 0.93 to 0.98 for all variables. SEM values ranged from 0.63 to 0.91N/Kg.

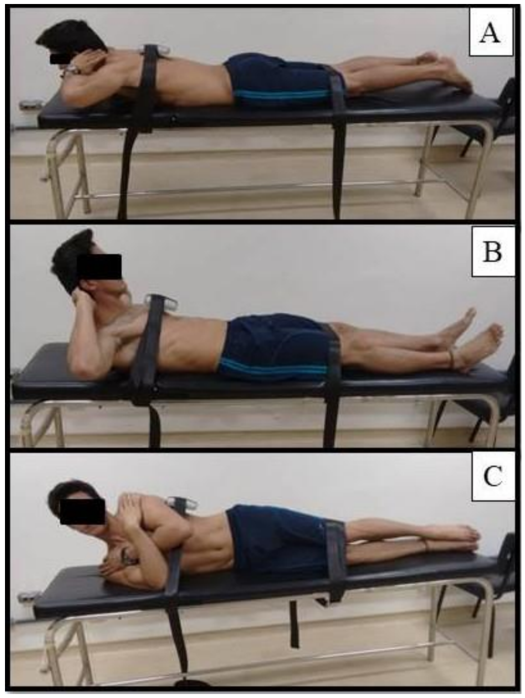

Figure 2. Participant positioned for maximal voluntary isometric contraction of the (A) trunk extensors, (B) trunk flexors and (C) trunk lateral flexors.

Transverse pelvic alignment

To evaluate transverse plane pelvic alignment during the bridge test with unilateral knee extension, a reflexive marker of 10 mm was placed on each participant's anterior superior iliac spine. Participants were positioned in supine with hands placed next to the body, with hips and knees flexed in a self-selected range of motion and with the feet soles close together and supported on the plinth. The self-selected knee flexion range of motion was used to guarantee that participants were comfortable during testing (Andrade *et al.*, 2012).

Participants were instructed to raise the pelvis from the plinth table and perform the extension of one knee, maintaining the trunk, hip and lower limb on a straight line at the same level as the thigh of the opposite side (Figure 3). Before beginning data collection, participants performed the test once with the purpose of familiarization. During data collection, the test position was held for 10s and then the test was repeated with the other lower limb (Andrade *et al.*, 2012). Time was checked by the examiner. The order of lower limbs to be tested was randomized (Wagner *et al.*, 2011; Chu *et al.*, 2016).

Figure 3. Participants position during the assessment of the transverse pelvic alignment. Examiner's view of the participant pelvic alignment in the transverse plane.

During the test, the examiners were positioned behind the participants' head, with the eyes leveled with the participant's pelvis. While one examiner was controlling the time and giving standardized verbal encouragement to keep the pelvic alignment, the other was recording the test using a video camera. The video camera (HDR-XR150, Sony, China) was placed on a tripod at a distance of 80cm of the extremity of the plinth. The tripod height was determined considering each participant anthropometric characteristics in a way that the plane for image capture would stay orthogonal to pelvic transverse plane during the test. This position allowed the pelvis to be centralized in the image captured during the test (Andrade *et al.*, 2012).

Prior to the study, 10 participants were tested on 2 occasions, separated by 3 days to establish test-retest reliability of bridge test with unilateral knee extension. The ICC and

SEM were 0.80 and 0.80° for the contralateral leg of the throwing arm, and 0.81 and 3.10° for the ipsilateral leg of the throwing arm.

Isokinetic Shoulder Peak Torque

Peak torque was measured for the throwing arm during shoulder internal and external rotation using the isokinetic dynamometer Biodex Multi-Joint System 3 (Biodex Medical System Inc., NY, USA) in the concentric mode and recorded at 100 Hz.

The participants were assessed in the seated position and stabilization of the trunk was provided with pelvic and diagonal straps. The arm was positioned at 90◦ of shoulder abduction and 90◦ of elbow flexion as previously suggested (Zanca, Oliveira, Saccol, Ejnisman, *et al.*, 2011). The dynamometer's axis of rotation was aligned with the olecranon. Gravity correction was performed with the arm relaxed at 90◦ of shoulder abduction, in neutral rotation with the forearm parallel to the ground (Zanca, Oliveira, Saccol e Mattiello-Rosa, 2011). Calibration was checked before every evaluation session.

Evaluations were performed through a ROM of 90◦ of shoulder internal and external rotation, from neutral rotation to 90◦ of external rotation, at three speeds: 90◦/s, 180◦/s and 240◦/s. To ensure familiarization before evaluation, 3 submaximal repetitions were performed at each velocity. A 1-minute rest period was provided between familiarization and testing that consisted of 5 maximal reciprocal repetitions. Participants were given a standardized verbal encouragement by the examiner to develop maximal strength in all contractions. A rest period of 2 minutes was given between each velocity (Zanca, Oliveira, Saccol e Mattiello-Rosa, 2011).

Test-retest reliability (3 days apart) for isokinetic shoulder peak torque measurements was performed on 8 participants prior to the study using the same methods described. The

ICC values ranged from 0.86 to 0.93 for all variables. SEM values ranged from 0.71 to 5.77Nm.

Data Processing

Data from the isokinetic tests were exported and processed using MatLab® (version 2008, Math Works Inc., Natick, USA). Torque data was utilized. Although the accuracy for velocity is given as 1°/s, we used an error of 10% for the periods of plateau and the preset velocity. In the cases that the preset velocity was not reached, the individual was excluded from statistical analysis. Only one participant did not reach the isokinetic phase in the concentric test at 240◦/s, particularly during external rotation. Thus, this participant was excluded from this analysis.

The software ImageJ (version 1.49, National Institute of Mental Health, Maryland, USA) was used to determine the degree of pelvic drop This represented the greater dropped achieved during the 10s of the test between the line of the anterior superior iliac spines and a horizontal line on pelvic transverse plane. The angle of pelvic drop was determined by the intersection of the straight line that passed in the center of each reflexive marker with the horizontal determined by the program (Andrade *et al.*, 2012).

Statistical Analysis

Mean and standard deviation were calculated for demographic data and the statistical analysis was performed using the SPSS Version 17.0 (SPSS Inc, Chicago, IL).

Shapiro-Wilk test was used to verify normality of the data. All variables, except peak torque of the shoulder internal rotation at 180º/s, endurance time of the trunk flexors and strength of the ipsilateral trunk flexors, were normally distributed. Associations between peak torque during internal and external rotation of the arm at different velocities and core endurance time, core strength and pelvic alignment were examined with the

Pearson's and Spearman's correlation tests for the data normally and non-normally distributed, respectively.

The level of significance was set at .05 for all statistical analyses. The strength of the correlation coefficient was considered poor correlation when values were between 0 and 0.25, weak between 0.26 and 0.50, moderate between 0.51 and 0.75, and strong between 0.76 and 1 (Portney, 2009).

RESULTS

Correlation between Core Endurance Time and Shoulder Peak Torque

Positive correlation was observed between endurance time of the trunk flexors and peak torque of shoulder external rotation at 90°/s, 180°/s and 240°/s. Positive correlation was also found between endurance time of the trunk ipsilateral flexors and peak torque of shoulder internal rotation at 180°/s. No significant correlations were found for the other outcomes (Table 2).

Table 2. Correlation between core endurance time and peak torque during isokinetic shoulder rotation

		Internal Rotation			External Rotation		
		90°/s	180°/s	240°/s	90°/s	180°/s	240°/s
Trunk extensors (s)	R	.31	.23	.28	.05	.07	.15
	P value	.15	.28	.19	.83	.73	.47
Trunk flexors (s)	R	.35	.30	.38	.57	.53	.51
	P value	.09	*.15*	.06	<.01[b]	<.01[b]	.01[b]
Trunk lateral flexors (s)							
Ipsilateral[a]	R	.40	.56	.39	.22	.21	.31
	P value	.09	<.01[b]	.06	.29	.32	.14
Contralateral[a]	R	.01	.13	-.00	.00	.09	.11
	P value	.97	.54	.99	.98	.67	.14

[a]Relative to the throwing arm
[b]*P*<.05 (Spearman test)

Correlation between MVIC of the Trunk Muscles and Shoulder Isokinetic Peak Torque

Positive correlations were observed between trunk flexors MVIC and peak torque of shoulder external and internal rotation at 90°/s, 180°/s and 240°/s. Positive correlation was also found between trunk ipsilateral flexors MVIC and peak torque of shoulder internal rotation at 90º/s. No significant correlations were found for the other variables (Table 3).

Table 3. Correlation between maximal voluntary isometric contraction and peak torque during isokinetic shoulder rotation

		Internal Rotation			External Rotation		
		90º/s	180º/s	240º/s	90º/s	180º/s	240º/s
Trunk extensors (N/kg)	R	-.00	.02	.03	-.21	-.13	.04
	P value	.99	.92	.89	.32	.53	.85
Trunk flexors (N/kg)	R	.59	.61	.51	.59	.44	.57
	P value	<.01[b]	<.01[c]	<.01[b]	<.01[c]	<.01[b]	.03[b]
Trunk lateral flexors (N/kg)							
Ipsilateral[a]	R	.44	.40	.26	.33	.38	.40
	P value	.03[c]	.06	.22	.12	.06	.05
Contralateral[a]	R	.13	.05	.09	-.01	-.07	-.19
	P value	.53	.83	.37	.94	.74	.67

[a]Relative to the throwing arm
[b]*P*<.05 (Pearson test)
[c]*P*<.05 (Spearman test)

Correlation between transverse pelvic alignment and Shoulder Isokinetic Peak Torque

No significant correlations were found between peak torque of shoulder internal and external rotation and the transverse pelvic alignment for both legs (Table 4).

Table 4. Correlation between transverse pelvic alignment and peak torque during isokinetic shoulder rotation

		Internal Rotation			External Rotation		
		90º/s	180º/s	240º/s	90º/s	180º/s	240º/s
Ipsilateral leg (degrees)[a]	R	-.20	-.08	-.20	-.09	-.11	-.09
	P value	.34	.72	.34	.67	.61	.69
Contralateral leg (degrees)[a]	R	.22	.15	.09	-.03	-.14	-.19
	P value	.31	.48	.68	.89	.52	.38

[a]Relative to the throwing arm

DISCUSSION

This study verified if there was relationship between core stability and concentric peak torque during internal and external rotation of the arm in throwing athletes with shoulder pain. The results showed weak to moderate positive correlations between internal and external rotation of the arm and both endurance and strength of the trunk flexors and trunk ipsilateral flexors. Peak torque of the shoulder was not correlated to any outcome of the trunk contralateral flexors, trunk extensors and transverse plane pelvic alignment.

When the shoulder is at maximal external rotation at the end arm cocking and beginning of the acceleration phase of the throwing, the abdominal oblique and rectus abdominis are in maximal eccentric contraction to prevent excess hyperextension of the lumbar spine (Seroyer *et al.*, 2009). Weakness of the abdominal musculature can lead to hyperextension of the lumbar spine, creating a “slow arm” in which the arm is behind the body with increased abduction and external rotation at the shoulder (Chu *et al.*, 2016). This indicates that compression loads at the shoulder may increase and lead to pain. This condition may explain the correlations found between the peak torque of the shoulder and strength and endurance of the trunk flexors in the athletes in the current study.

The correlation found between peak torque of the shoulder and strength and endurance of the trunk flexors and trunk ipsilateral flexors may be related to how the trunk and shoulder moves during the throwing. At the end of the acceleration phase of the throwing, the trunk moves from hyperextension to a forward flexed and rotated position (Chu *et al.*, 2016). The shoulder moves from shoulder external rotation to internal rotation, and there is increased activation of the subscapularis, pectoralis major, and latissimus dorsi that cause the large amount of internal rotation of the humerus to release the ball (Seroyer *et al.*, 2009).

The latissimus dorsi not only internally rotates the arm but is also an important lateral flexor of the trunk. A recent study has shown the existence of myofascial force transmission from gluteus maximus to latissimus dorsi through thoracolumbar fascia (Carvalhais *et al.*, 2013). Interestingly, Kaur et al.(2014) have supported these findings by showing that the latissimus dorsi operates as a connection in the myofascial chain to transfer the energy from the lower limbs and trunk muscles to the serratus anterior. Thus, decreased endurance of this muscle may influence the activation of the anterior serratus, impairing the function of the shoulder during a game.

Another study (Toro *et al.*, 2015) has also shown the existence of synergism among external and internal oblique and rectus abdominis with scapulothoracic muscles during shoulder activities. Therefore, poor strength and endurance of the trunk flexors and trunk lateral flexors may affect this muscular synergy, such as early muscle fatigue during the game, and predispose the shoulder to injury.

In the present study, no correlations were found between the peak torque of the shoulder and strength and endurance of the trunk extensors and the transverse lumbopelvic control. These tests have been previously used to evaluate stability of the lumbopelvic-hip complex in healthy individuals (Mcgill *et al.*, 1999; Andrade *et al.*, 2012) and with patellofemoral pain (Nakagawa *et al.*, 2015). These studies have identified increased activity of the hip and spine extensors during the execution of these tests (Schellenberg *et al.*; Stevens *et al.*, 2006; Muller *et al.*, 2010). It suggests that athletes with shoulder pain do not show poor posterior core stability. However, more studies are necessary to elucidate this speculation.

Limitations

This study has some limitations. The bridge test with unilateral knee extension had the time limited to 10s, and possibly did not challenge the lumbopelvic motor control, that may have influenced the outcome of the present study. In addition, future investigations should analyze the electromyographic activity of the muscles of the respective tests to support the data. Another limitation is that this sample was mostly composed by handball athletes, which limits the interpretation of these results for other sports overheads and not compared to athletes without pain.

Clinical implications

This study highlights the importance of the myofascial connections through kinetic chain that allows transfers of energy between lower extremity, trunk muscles and upper extremity. It may be used by clinicians for planning interventions. The current results suggest that exercises for trunk flexor and lateral flexor muscles, particularly those that emphasize isometric strength and endurance, should be stimulated in the throwing athletes with shoulder pain as part of the rehabilitation plan.

CONCLUSION

Decreased strength and endurance of the trunk flexors and trunk ipsilateral flexors is associated with lower capacity to generate shoulder internal and external rotation torque with the throwing arm in athletes with shoulder pain. Posterior core muscle function does not seem to influence on the shoulder torque rotation. Such results support the kinetic chain theory based on the interdependence of segments to generate and transfer of forces during functional movements. Future studies should analyze if altered abdominal musculature could lead to shoulder injuries.

CONSIDERAÇÕES FINAIS

Baseado nos resultados, conclui-se que os atletas arremessadores com dor no ombro apresentaram:

- Menor tempo de resistência dos músculos flexores laterais de tronco comparados a atletas sem dor no ombro. Porém, não apresentaram diferenças no tempo de resistência dos músculos flexores e extensores do tronco.

- Menor equilíbrio dinâmico de membro inferior para a direção posteromedial de ambas as pernas e para a direção posterolateral da perna de apoio. Apresentaram também menor composto para ambas as pernas quando comparado com os atletas sem dor no ombro. No entanto, nenhuma diferença foi observada para direção anterior.

- Nenhuma diferença no pico de torque isocinético concêntrico dos rotadores laterais e mediais de ombro em todas as velocidades analisadas comparados aos atletas sem dor. O mesmo resultado foi observado para análise da amplitude de movimento dos rotadores de ombro. No entanto, esses atletas apresentaram menores pontuações para os questionários e avaliação do nível de satisfação com o braço de arremesso comparado aos atletas sem dor.

- Correlação positiva de fraca a moderada do pico de torque de rotação medial e lateral de ombro com ambas as forças isométrica e de resistência dos músculos flexores e flexores ipsilaterais do tronco. No entanto, não apresentaram correlação entre as forças isométricas e de resistência dos músculos extensores, flexores contralaterais do tronco e os rotadores de ombro, bem como, para alinhamento pélvico transverso.

Os resultados gerais suportam a teoria da cadeia cinética baseada na interdependência dos segmentos para gerar e transferir as forças durante o movimento de arremesso. Além de sugerir que exercícios que trabalhem o controle neuromuscular de membro inferior e força isométrica e resistência, particularmente para os músculos flexores e flexores laterais do tronco, devem ser estimulados nos atletas jogando com dor no ombro como parte do plano de reabilitação.

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ANEXO I

UNIVERSIDADE FEDERAL DE
SÃO CARLOS/UFSCAR

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: ANÁLISE DA CADEIA CINÉTICA EM ARREMESSADORES COM E SEM DOR NO OMBRO

Pesquisador: Lívia Silveira Pogetti

Área Temática:

Versão: 1

CAAE: 32509614.6.0000.5504

Instituição Proponente: Centro de Ciências Biológicas e da Saúde

Patrocinador Principal: MINISTERIO DA EDUCACAO

DADOS DO PARECER

Número do Parecer: 735.589

Data da Relatoria: 08/07/2014

Apresentação do Projeto:

Trata-se de uma pesquisa de Doutorado baseada na hipótese de que atletas arremessadores com dor apresentem pior desempenho muscular em todos os componentes da cadeia cinética quando comparados com arremessadores sem dor e ainda, os atletas arremessadores com pior função e dor apresentarão menor desempenho muscular do quadril, tronco e ombro. Dentro deste contexto, o presente projeto pesquisa está apresentado de forma adequada e com todos os elementos necessários para ser julgado como tal.

Objetivo da Pesquisa:

O objetivo principal do estudo será avaliar o desempenho muscular da cadeia cinética (quadril, tronco e ombro) de atletas arremessadores com e sem dor no ombro. Para isso será a função da escápula, ombro, tronco, pelve e membro inferior e a dor, e analisar a correlação entre estas variáveis e o desempenho muscular da cadeia cinética nos atletas com dor no ombro.

Avaliação dos Riscos e Benefícios:

Os riscos de sua participação são mínimos, pois pode haver uma pequena fadiga após a realização do do teste isométrico e de resistência de tronco devido à contração máxima realizada. Esse desconforto, entretanto, será momentâneo. Durante a avaliação do isocinético de ombro é possível que ocorra dor. No entanto, logo em seguida a sua realização será aplicado gelo para minimizar este efeito. Os benefícios com esse estudo é ajudar o profissional clínico a traçar uma melhor preparação física dos atletas, evitando assim, possíveis lesões geradas pelo esporte, como também auxiliar na reabilitação desta população lesionada.

Comentários e Considerações sobre a Pesquisa:

A dor no ombro é o principal problema entre os atletas arremessadores. Assim, pode-se notar a importância de se realizar estudos que permitam um melhor entendimento dos componentes da cadeia cinética em atletas arremessadores com e sem dor no ombro a fim de obter melhores protocolos de tratamento e avaliação, e consequentemente, do rendimento desta população.

Considerações sobre os Termos de apresentação obrigatória:

A proponente do projeto apresentou Folha de Rosto preenchida e devidamente assinada. O TCLE foi apresentado apontando os riscos e os benefícios para o objeto da pesquisa.

Recomendações:

Conclusões ou Pendências e Lista de Inadequações:

O projeto possui conteúdo e hipótese de trabalho consistente. Não há pendências e lista de inadequações a serem apontadas.

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

Considerações Finais a critério do CEP:

SAO CARLOS, 01 de Agosto de 2014

Assinado por:
Ricardo Carneiro Borra
(Coordenador)

Endereço: WASHINGTON LUIZ KM 235
Bairro: JARDIM GUANABARA **CEP:** 13.565-905
UF: SP **Município:** SAO CARLOS
Telefone: (16)3351-9683 **E-mail:** cephumanos@ufscar.br

APÊNDICE I

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

1. Você está sendo convidado para participar da pesquisa “A influencia da dor no ombro sobre a estabilidade do core em atletas overhead”.
2. Você foi selecionado por meio de testes clínicos, por apresentar sintomas dolorosos no ombro e não apresentar sintomas dolorosos no pescoço.
3. O objetivo principal deste estudo será investigar a influência da dor no ombro sobre a estabilidade do core em atletas overhead. O objetivo secundário será investigar o desempenho muscular das articulações do ombro, quadril e tronco na mesma população.
4. Sua participação nesta pesquisa consistirá em: (1) entrevista com o pesquisador para avaliar se você preenche os requisitos previstos nos critérios de inclusão do estudo; (2) fornecer informações tais como: idade, peso, altura, histórico da dor no ombro, tipo de esporte; (3) quatro avaliações compostas por: a) avaliação funcional da articulação do ombro e do quadril, através de aplicações de escalas e de testes específicos; b) avaliação isocinética do ombro por meio da realização de movimentos combinados de rotação interna e lateral; e do quadril por meio do movimento de extensão; para estas avaliações será utilizado o biodex system 3; c) avaliação isométrica da musculatura do tronco será através de movimentos de flexão, extensão e ponte lateral; nesta avaliação os sujeitos deverão vencer uma resistência elástica, em que a força gerada será medida através de um dinamômetro manual; d) avaliação de endurance dos músculos do core será através da realização de movimentos de flexão, extensão e ponte lateral do tronco; nesta avaliação os sujeitos deverão manter-se nestas posições, a qual será medida através de um cronômetro e registrada por uma câmera de vídeo.
5. O procedimento não tem caráter invasivo. Os riscos de sua participação são mínimos, pois pode haver uma pequena irritação (vermelhidão) da pele após a realização do isocinético de quadril, e do isométrico de tronco devido à força máxima realizada. Esse desconforto, entretanto, será momentâneo. Durante a avaliação do isocinético de ombro você possivelmente sentirá dor. No entanto, logo em seguida a sua realização será aplicado gelo para minimizar este efeito. Com este estudo espera-se ajudar o profissional clínico a traçar uma melhor preparação física dos atletas, evitando assim, possíveis lesões geradas pelo esporte, como também auxiliar na reabilitação desta população lesionada.
6. Todos os procedimentos serão realizados pelo pesquisador abaixo identificado.
7. Quaisquer dúvidas a respeito dos procedimentos e da sua participação na pesquisa serão esclarecidas antes e durante o curso de pesquisa pelo pesquisador responsável.
8. A qualquer momento você pode desistir de participar e retirar seu consentimento, sendo que isso não trará nenhuma penalização ou prejuízo em sua relação com o pesquisador ou com a instituição.
9. As informações obtidas através dessa pesquisa serão confidenciais e asseguramos o sigilo sobre sua participação.
10. Os dados não serão divulgados de forma a possibilitar sua identificação, sendo que os arquivos gerados no processo de avaliação serão identificados a partir de uma numeração.
11. Você receberá uma cópia deste termo onde consta o telefone e o endereço do pesquisador principal, podendo tirar suas dúvidas sobre o projeto e sua participação, agora ou a qualquer momento.

____

Lívia Silveira Pogetti

Rodovia Washington Luís, km 235 - SP-310. São Carlos/SP. Fone: (16) 9125-7584

Declaro que entendi os objetivos, riscos e benefícios de minha participação na pesquisa e concordo em participar.

São Carlos, _________ de____________________de______________________

Participante da pesquisa - Nome____

Assinatura____

APÊNDICE II

FICHA DE AVALIAÇÃO

Data: ____________

Nome: ____

Data de Nascimento: ________________ Idade:_________ Peso:___________ Altura:_____________

IMC:_______ Sexo:______ Estado Civil:______________ Profissão:________________

Endereço: ____

E-mail:___________________________________ Telefone:___________

Qual o esporte que pratica? _______________________ Posição ______________

Há quanto tempo?______________ Frequência Semanal? ___________

MS dominante: D ( ) E ( ); MS arremessa: D ( ) E ( ); Tem dor? Sim ( ) Não ( ) - Lado: __________________

Onde? ___________________________________ Quando?____

HMA:____
____
____
____
____

EXAME FÍSICO

ADM de elevação do braço dominante: D(_______/_______) E(________/________)

Distância entre o trocânter maior ao acrômio: D (___________) E (___________)

Distância entre crista ilíaca e maléolo medial: Impulsão (__________) Apoio (__________)

Inclinômetro:

	Medida 1	**Medida 2**
Rotação Medial		
Rotação Lateral		

Discinesia Escapular: Sem carga? Presente ( ) Ausentes ( ); Lado : D(_____) E (_______)

Com carga? 1.4 kg Presente ( ) Ausentes ( ) - Lado: D (______) E (_______) ;

2.0 kg Presente ( ) Ausentes ( ); - Lado: D (____) E (_____)

Obs:____

____

Testes Especiais para avaliação do ombro:

	Ombro Direito	Ombro Esquerdo
Neer		
Jobe		
Hawkins-Kennedy		
Gavela AP		
Teste de queda		
Teste do sulco		
Arco doloroso		
Compressão cervical		
Rotação lateral resistida		
Rotação lateral com abdução		

AVALIAÇÃO FUNCIONAL

Teste de ponte com extensão unilateral de joelho:

	MI Direito	MI Esquerdo
Nenhuma inclinação		
Inclinação pélvica leve (0-25% da excursão de inclinação possível)		
Inclinação pélvica moderada (25-75% da excursão de inclinação possível)		
Inclinação pélvica acentuada (75-100% da excursão de inclinação possível)		
Total		

Teste de equilíbrio-y; realizado com a perna dominante.

- Perna Impulsão:__________________
- Perna de Apoio: ____________________
- Soma das distâncias perna de impulsão (ANT, PM, PL): _________________
- Soma das distâncias perna de apoio (ANT, PM, PL): _________________

Pontuação final da escala EROE: _______________

Pontuação final do SPADI: __________________

POSICIONAMENTO DO BIODEX

	1º DIA			2º DIA		
	RI/RE	Quadril		RI/RE	Quadril	
		D	E		D	E
Distância da cadeira						
Distância do encosto						
Distância do dinamômetro						
Altura da cadeira						
Altura do dinamômetro						
Tamanho do braço de alavanca						
Inclinação do encosto						

AVALIAÇÃO DE DOR

Escala Numérica de Dor

<u>1º Dia</u>	**Isocinético**				
	RI/RL			**Qua.**	
	90º/s	**180º/s**	**240º/s**	**D**	**E**
				60º/s	**60º/s**
Antes					
Durante					
Após					

<u>2º Dia</u>	**Isocinético**				
	RI/RL			**Qua.**	
	90º/s	**180º/s**	**240º/s**	**D**	**E**
				60º/s	**60º/s**
Antes					
Durante					
Após					

Obs:____
____
____

<u>1º Dia</u>	**Isométrico**			
	Fle.Lat.		**Flex.Tronco**	**Ext.Tronco**
	Ipsilateral	**Contralateral**		
Antes				
Durante				
Após				

<u>2º Dia</u>	**Isométrico**			
	Fle.Lat.		**Flex.Tronco**	**Ext.Tronco**
	Ipsilateral	**Contralateral**		
Antes				
Durante				
Após				

Obs:____
____
____

<u>1º Dia</u>	**Resistência**			
	Fle.Lat.		**Flex.Tronco**	**Ext.Tronco**
	Ipsilateral	**Contralateral**		
Antes				
Durante				
Após				

<u>2º Dia</u>	**Resistência**			
	Fle.Lat.		**Flex.Tronco**	**Ext.Tronco**
	Ipsilateral	**Contralateral**		
Antes				
Durante				
Após				

Obs:____

ANOTAÇÕES – dinamômetro e cronômetro

TESTE ISOMÉTRICO

1º Dia	**Isométrico**																			
	Fle.Lat.										**Flex.Tronco**					**Ext.Tronco**				
	D					**E**					**1º**	**2º**	**3º**	**4º**	**5º**	**1º**	**2º**	**3º**	**4º**	**5º**
	1º	2º	3º	4º	5º	1º	2º	3º	4º	5º										

2º Dia	**Isométrico**																			
	Fle.Lat.										**Flex.Tronco**					**Ext.Tronco**				
	D					**E**					**1º**	**2º**	**3º**	**4º**	**5º**	**1º**	**2º**	**3º**	**4º**	**5º**
	1º	2º	3º	4º	5º	1º	2º	3º	4º	5º										

Obs:

TESTE DE RESISTÊNCIA

1º Dia	**Resistência**			
	Flex.Lat.		**Flexão**	**Extensão**
	D	**E**		

2º Dia	**Resistência**			
	Flex.Lat.		**Flexão**	**Extensão**
	D	**E**		

Obs: