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Baseball Players Diagnosed With Ulnar Collateral Ligament Tears Demonstrate Decreased Balance Compared to Healthy Controls

Ulnar collateral ligament (UCL) tears are a common cause of medial elbow pain in overhead throwers.^{7,17} The UCL is the primary stabilizer against valgus stress at the elbow,^{8,13} and disruption of this ligament can lead to instability during the late cocking phase of the throwing motion.^{7,12} It has been reported that the number of UCL reconstructions in high school baseball players

has risen dramatically, due in part to the year-round opportunities for competition and training.¹⁷

The etiology of UCL injury is likely multifactorial. Kibler and Sciascia¹¹ proposed that inadequate range of motion (ROM) and poor balance may significantly affect an athlete's ability to transfer energy along the kinetic chain, resulting in dysfunctional movement and increased stresses at various segments, including the elbow. Though Dines et al⁴ found reduced shoulder internal rotation ROM in high school, college, and professional baseball players with UCL insufficiency, and Garrison et al⁵ found reduced total rotational motion (TRM) of the throwing shoulder in baseball players with UCL tears, little attention has been given to how balance may contribute to these injuries.

Balance has been defined as the dynamics of body posture to prevent falling and is affected by the inertial forces acting on the body.²⁶ This may involve movement around a base of support and performing tasks, such as standing on 1 limb while reaching with another segment, without disrupting the established base of support.^{6,11} In baseball, impaired control at the trunk and lower extremities may alter the position of the shoulder and elbow throughout the

● **STUDY DESIGN:** Cross-sectional.

● **OBJECTIVES:** To compare lower extremity balance and shoulder range of motion in baseball players with ulnar collateral ligament (UCL) tears to a healthy cohort.

● **BACKGROUND:** Throwing is a complex motion that requires balance and coordination to effectively transfer energy through the kinetic chain. In theory, poorer balance could negatively affect throwing mechanics and lead to injury.

● **METHODS:** Thirty baseball players (mean \pm SD age, 18.5 \pm 1.9 years) with a diagnosis of a UCL tear of their throwing arm were compared to 30 players (age, 19.0 \pm 1.1 years) without a UCL tear. All participants were competing at either the high school or collegiate level and reported an average \pm SD of 13.5 \pm 1.7 years of playing experience. The Y Balance Test composite scores were calculated for the stance and lead lower extremities of all players. Shoulder range of motion was used to calculate glenohumeral internal rotation deficit and side-to-side differences in total rotational motion. Group comparisons were made between participants with and without UCL tears using

independent *t* tests.

● **RESULTS:** Baseball players with UCL tears scored significantly lower on the Y Balance Test for both the stance ($P < .001$) and lead ($P < .001$) lower extremities compared to the noninjured cohort. No between-group differences were noted in glenohumeral internal rotation deficit ($P = .453$), whereas the mean \pm SD side-to-side difference in total rotational motion was $-6.0^\circ \pm 9.6^\circ$ for the injured group, compared to $-0.4^\circ \pm 9.6^\circ$ for the control group ($P = .028$).

● **CONCLUSION:** Participants with a UCL tear demonstrated decreased performance for their stance and lead lower extremities during the Y Balance Test. These data are consistent with a clinical hypothesis of a potential association between impaired balance and UCL tears in high school and collegiate baseball players. The lower total rotational motion of the dominant shoulder in participants with UCL tears needs to be considered in the interpretation of those results. *J Orthop Sports Phys Ther* 2013;43(10):752-758. Epub 9 September 2013. doi:10.2519/jospt.2013.4680

● **KEY WORDS:** elbow, GIRD, pitching

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throwing motion and potentially result in increased stress placed across both joints.

Functional assessments provide clinicians with valuable information to help in prevention, diagnosis, and treatment of athletic injuries. Upper extremity assessment has been previously utilized in individuals with UCL tears^{4,5}; however, an overall assessment of balance has not been described in this population. It has been suggested that throwing requires balance and coordination to effectively transfer energy from the lower body and trunk through the upper extremity to the point of ball release.^{2,11} It is theorized that a loss of balance, or inability to stabilize the body over a base of support, might impede muscle activation and subsequent optimal force development. Accordingly, dysfunction in the lower segments of the body could negatively impact an athlete's throwing motion, potentially increasing overall risk for injury.²

An athlete must demonstrate adequate neuromuscular control at the ankle, knee, and hip while in single-leg stance to execute a dynamic reach with the nonstance limb without a loss of balance.¹⁶ The Y Balance Test assesses ROM, strength, and neuromuscular control of the lower extremity and has been proven to be reliable¹⁸ and a valid predictor of injury risk in athletic populations.¹⁹ Basketball players with an anterior-reach side-to-side difference of greater than 4 cm were found to be 2.5 times more likely to experience a lower extremity injury.¹⁹ To our knowledge, no studies have been published to date investigating the relationship between lower extremity balance and upper extremity injuries in baseball players. Thus, the purpose of this study was to compare lower extremity balance and shoulder ROM of baseball players with and without a UCL tear.

METHODS

Participants

SIXTY MALE COMPETITIVE HIGH school and collegiate baseball players volunteered to participate in this

cross-sectional study. Participants reported playing baseball for an average \pm SD of 13.5 ± 1.7 years (range, 9-17 years). All participants gave informed consent to participate, and the rights of each person were protected.

In this study, 30 participants (mean \pm SD age, 18.5 ± 1.9 years) with a diagnosis of UCL tear of their throwing arm were compared to 30 players with no UCL tear, who were matched by age (19.0 ± 1.1 years), years of experience, arm dominance, level of play, and position. The diagnosis of UCL tear was based on clinical examination by a fellowship-trained, board-certified orthopaedic surgeon (J.E.C.) and on results of magnetic resonance imaging. Of the 60 participants, 50 were pitchers, 5 were infielders, and 5 were catchers. Sample size was 20 per group, based on a minimal clinically important difference of 4 percentage points in the Y Balance Test composite scores between groups, with a power of 0.80, $P < .05$, and a standard deviation of 2.5% for the Y Balance Test composite scores.

Players with injured UCLs were identified through clinical visits to the participating physician (J.E.C.) or physical therapists (J.C.G. and M.J.M.). Inclusion criteria were (1) being a baseball player between the ages of 15 and 25, (2) ability to throw affected by the injury, (3) unable to continue to participate in baseball at the level prior to UCL tear, (4) clinical exam positive for UCL tear, (5) confirmation of UCL diagnosis via magnetic resonance imaging, and (6) attempting to return to sport at a competitive level.

Exclusion criteria were (1) a previous UCL reconstruction that failed, (2) previous shoulder injury or surgery (to include labral or rotator cuff involvement), and (3) not planning to return to baseball following treatment. The same exclusion criteria were applied to the participants in the control group.

The control group was recruited from local high schools and colleges prior to the beginning of the fall season. Players were matched to the UCL group by age, years of experience, dominant arm,

level of play, and position. None of the players chosen for the control group had any history of previous UCL tear or any shoulder or elbow injury at the time of the measurements. Those players with a previous shoulder or elbow injury requiring surgery were excluded from the matching process.

An investigator in the outpatient sports physical therapy facility administered the informed-consent process once the participants met the criteria for inclusion. Child assent and parental permission were obtained for those participants who were minors at the time of the study. At the initial evaluation, objective measurements were taken on the participants' shoulder and elbow, and measurements for the Y Balance Test were also recorded. The Institutional Review Board of Texas Health Resources approved the research procedures.

Shoulder ROM Testing

For the participants with a UCL tear, shoulder ROM and balance testing was performed at the initial visit to the outpatient sports physical therapy facility. All control participants were measured prior to their fall season, using the same methods as those applied to the UCL group. Measurements were taken by 2 physical therapists and 1 athletic trainer; however, the same person (J.C.G.) stabilized the scapula for each of the shoulder measurements. Internal and external rotation ROM was measured bilaterally on each participant.²⁵ For glenohumeral joint external rotation, the participant was positioned supine, with the arm elevated to 90° in the scapular plane. The scapula was stabilized by the therapist, and the arm was passively rotated to end range. Measurements were taken using a bubble goniometer, with the stationary arm in a vertical direction, the axis of the goniometer aligned with the olecranon process, and the moving arm along the ulna. For internal rotation, the positioning of the participant and the goniometer was the same, with end range reached when scapular



FIGURE 1. Shoulder internal rotation range-of-motion measurement.

motion was felt beneath the therapist's hand (FIGURE 1).

Reliability of the ROM measurements for shoulder internal (intraclass correlation coefficient [ICC]_{3,1} = 0.97; standard error of measurement [SEM], 1.6°) and external (ICC_{3,1} = 0.97; SEM, 1.5°) rotation for those participating in the study was considered to be acceptable.

For this study, glenohumeral internal rotation deficit (GIRD) was calculated by comparing the amount of internal rotation of the throwing arm to that of the nonthrowing arm, with a negative value indicating lesser internal rotation on the throwing side. Shoulder TRM was calculated by adding the amount of internal and external rotation for each shoulder. Side-to-side difference in TRM was based on comparing the throwing arm to the nonthrowing arm, with a negative value indicating lesser TRM for the throwing arm. This method has been described in earlier studies.^{23,24} GIRD and side-to-side difference in TRM for each group were used for analysis.

Balance Testing

The Y Balance Test was utilized as a measure of trunk and lower extremity function. Measurements were taken in 3 directions, anterior (FIGURE 2), posteromedial (FIGURE 3), and posterolateral (FIGURE 4), on both the stance and lead lower extremities. The stance limb was deter-



FIGURE 2. Y Balance Test anterior reach.

mined as the lower extremity on which the thrower began the throwing motion, which was the same side as the arm used to throw the ball.

The participants were instructed in the Y Balance Test protocol using a combination of verbal cues and demonstration.¹⁸ The Y Balance Test Kit was utilized throughout the study. All participants wore shoes during testing and began on their stance limbs. They were asked to perform single-limb stance, while reaching with the opposite lower extremity to push a reach indicator box along the measurement pipe.¹⁸ Elevation of the heel or toes, or loss of balance resulting in a stepping strategy, was recorded as a trial error and the trial was repeated. Participants were allowed at least 3 practice trials in the anterior, posteromedial, and posterolateral directions prior to recording the best of 3 formal trials in each plane. Three trials were completed on the stance limb in the anterior direction, followed by 3 trials completed on the lead limb.¹⁸ This protocol was then replicated for the posteromedial and posterolateral directions.

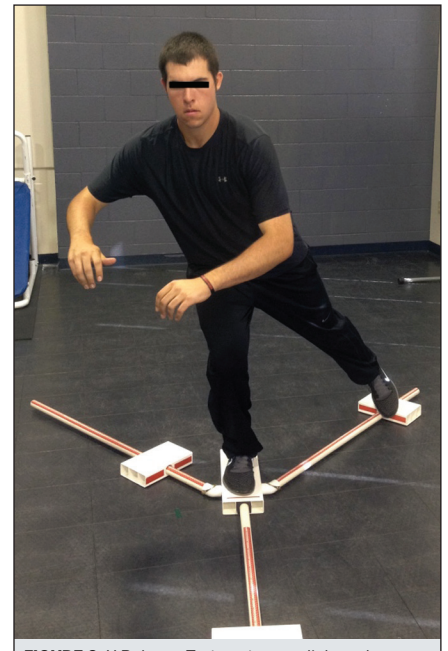


FIGURE 3. Y Balance Test posteromedial reach.

For each testing direction, maximal reach distance was recorded as the distance reached by the most distal part of the foot, as indicated by the measurement pipe. The composite scores were calculated by adding the reach distances (measured in cm) of the anterior, posteromedial, and posterolateral directions. This total was then divided by 3 times the participant's limb length, and multiplied by 100 to obtain a percentage.^{18,19} Limb length was determined using the distance between the most prominent portion of the greater trochanter and the floor while the individual was in a standing position.

All balance measurements were taken by 2 physical therapists and 1 athletic trainer. Reliability of the measurements for the anterior (ICC_{3,1} = 0.86; SEM, 3.3 cm), posteromedial (ICC_{3,1} = 0.99; SEM, 1.7 cm), and posterolateral (ICC_{3,1} = 0.95; SEM, 2.7 cm) directions for the testers participating in the study was considered to be acceptable. These values are similar to previously published data on intrarater (ICC_{3,1} = 0.91) and interrater (ICC_{2,1} = 0.99) reliability of composite scores for this test.¹⁸

Data Analysis

Separate independent *t* tests were used to



FIGURE 4. Y Balance Test posterolateral reach.

compare the 2 groups on the Y Balance Test composite scores for the stance limb, Y Balance Test composite scores for the lead limb, GIRD, and side-to-side difference in TRM. The significance level was set at $P < .05$.

RESULTS

TABLE 1 PROVIDES THE DEMOGRAPHIC characteristics and TABLES 2 and 3 provide the balance and shoulder ROM data of the participants in both groups. Baseball players with UCL tears scored significantly lower on the Y Balance Test composite scores on both their stance (mean \pm SD, $88.2\% \pm 7.9\%$) and lead ($89.1\% \pm 6.7\%$) limbs compared with the control group ($95.4\% \pm 6.4\%$ and $95.8\% \pm 6.1\%$, respectively; $P < .001$). The mean \pm SD side-to-side difference in shoulder TRM in baseball players with UCL tears was $-6.0^\circ \pm 9.6^\circ$, compared to $-0.4^\circ \pm 9.6^\circ$ for the control group ($P = .028$). Mean \pm SD GIRD values for the group with a UCL tear ($-12.3^\circ \pm 8.9^\circ$) and the control group ($-13.9^\circ \pm 7.0^\circ$) were similar ($P = .453$).

DISCUSSION

IN THIS STUDY, BASEBALL PLAYERS DIAGNOSSED with a UCL tear demonstrated decreased balance on both their stance ($d = 1.1$) and lead ($d = 1.1$) lower extremi-

TABLE 1		CHARACTERISTICS OF BASEBALL PLAYERS WITH UCL TEARS AND CONTROL GROUP		
	Control (n = 30)	UCL Tear (n = 30)	P Value	
Age, y*	19.0 \pm 1.1	18.5 \pm 1.9	.252	
Throwing arm, n			1.000	
Right	25	25		
Left	5	5		
Playing experience, y*	13.5 \pm 1.3	13.3 \pm 2.1	.610	
Position, n			.819	
Pitcher	25	25		
Catcher	2	3		
Infielder	3	2		
Level of play, n			.438	
College	16	13		
High school	14	17		

Abbreviation: UCL, ulnar collateral ligament.
**Values are mean \pm SD.*

TABLE 2		BALANCE AND SHOULDER RANGE-OF-MOTION DATA FOR BOTH GROUPS		
	Control (n = 30)*	UCL Injured (n = 30)*	P Value	
Y Balance Test: composite lead limb, %	95.8 \pm 6.1	89.1 \pm 6.7	<.001	
Y Balance Test: composite stance limb, %	95.4 \pm 6.4	88.2 \pm 7.9	<.001	
TRM difference, [†] deg	-0.4 \pm 9.6	-6.0 \pm 9.6	.028	
GIRD, [‡] deg	-13.9 \pm 7.0	-12.3 \pm 8.9	.453	

Abbreviations: GIRD, glenohumeral internal rotation deficit; TRM, total rotational motion; UCL, ulnar collateral ligament.
**Values are mean \pm SD.*
[†]*Defined as the side-to-side difference in the sum of shoulder external and internal rotation of the throwing arm in comparison to the nonthrowing arm, with a negative value indicating lesser TRM on the throwing arm.*
[‡]*Deficit in internal rotation range of motion of the throwing arm in relation to the nonthrowing arm, with a negative value indicating lesser internal rotation on the throwing arm.*

ties when compared to a control group of baseball players without a UCL injury. In addition, though GIRD was very similar between groups ($d = 0.22$), the shoulder side-to-side TRM deficits in the group with a UCL tear were greater ($d = 0.58$) than those in the control group. Therefore, while the data suggest a relationship between decreased balance and UCL tears in baseball players, interpretation of this relationship should consider the lower shoulder TRM in the throwing arm of those with UCL injury. The cross-sectional design of the study also precludes conclusion of cause and effect.

The throwing motion incorporates a series of integrated, multiplanar movements at different joints, utilizing coordinated strength and neuromuscular control.²¹ It has been hypothesized that in baseball players, the pattern of muscle activation and transfer of energy begins in the lower extremities and is transferred through the trunk to the upper extremities to achieve maximal throwing velocity.¹¹ An inefficient movement pattern that begins at the lower extremity, possibly identified through reduced balance, could alter throwing mechanics and lead to upper extremity injuries.

TABLE 3

DESCRIPTIVE DATA FOR SHOULDER RANGE OF MOTION FOR BOTH GROUPS*

	Control (n = 30)	UCL Injured (n = 30)	P Value
Dominant-shoulder			
ER	119.6 ± 10.5	112.5 ± 10.8	.012
IR	21.6 ± 6.3	28.1 ± 7.3	<.001
TRM†	141.2 ± 12.3	140.6 ± 11.6	.847
Nondominant-shoulder			
ER	106.0 ± 11.6	106.2 ± 12.9	.958
IR	35.6 ± 6.9	40.4 ± 6.8	.009
TRM†	141.6 ± 12.8	146.6 ± 13.6	.150

Abbreviations: ER, external rotation; IR, internal rotation; TRM, total rotational motion; UCL, ulnar collateral ligament.
 *Values are mean ± SD deg.
 †TRM is the sum of shoulder external and internal rotation.

A previous report, using a prospective research design, has shown that a decrease in balance was associated with a greater likelihood of lower extremity injury in female high school basketball players.¹⁹ In that study, females who had a composite score of less than 94% on the Y Balance Test were 6.5 times more likely to incur an injury to the lower extremity during the subsequent season. Likewise, when the results were compiled for both males and females, a composite reach distance of less than 94% led to those athletes being 3 times more at risk for lower extremity injury during the following basketball season.¹⁹ In our study, limited to male baseball players, the composite scores for those with UCL tears were below 94% for both the stance (88.2% ± 7.9%) and lead (89.1% ± 6.7%) limbs. Although these results cannot be causally linked to a UCL tear, they are consistent with the hypothesis of a potential relationship between injury to the elbow and balance. Factors that might have contributed to deficits in balance in the group with UCL injuries include ROM and strength impairments at the ankle, knee, and hip,¹⁹ as well as deficiencies in core stability.³

In this study, the players with UCL tears also demonstrated a greater side-to-side deficit in shoulder TRM (mean ± SD, -6.0° ± 9.6°) when compared to un-

injured players matched by age, position, and activity level (-0.4° ± 9.6°, *P* = .028). These findings are consistent with previously reported data.^{4,5} Dines et al⁴ found a difference (mean ± SD, 9.65° ± 3.3°) in TRM of the dominant arms of UCL-insufficient and healthy high school, college, and professional baseball players. More recently, Garrison and colleagues⁵ identified a mean ± SD side-to-side difference in TRM of -6.67° ± 11.82° in high school and college baseball players diagnosed with a UCL tear, compared to 0.93° ± 9.91° in healthy matched controls. In professional baseball players, Wilk et al²³ showed an association between GIRD and TRM and shoulder injuries in pitchers. A side-to-side deficit in TRM greater than 5° was associated with a pitcher being 2.5 times more likely to sustain a shoulder injury. Though this article²³ was not specific to baseball players with UCL tears, it did assist in establishing a precedent of TRM deficits and their potential relationship to upper extremity injuries. In the present study, the baseball players diagnosed with UCL tears exhibited a 5.57° greater deficit in TRM when compared to the controls. Our value did not exceed the deficit reported by Dines et al⁴ but did fall outside the acceptable range of a 5° TRM deficit, which has been suggested to place pitchers at increased risk for injury.²³ Further research is need-

ed to establish the clinically meaningful level of TRM deficits that would be associated with injury.

GIRD, or a deficit of shoulder internal rotation of the throwing arm compared to the nonthrowing arm, has been repeatedly linked to upper extremity injury in overhead throwers.^{2,4,17,22,23} Our study did not show a difference in GIRD between the UCL and healthy groups. Shanley et al²² identified preseason deficits in shoulder internal rotation as a risk factor for arm injury in overhead throwers. In retrospective studies, GIRD was found in overhead throwers with internal impingement,¹⁴ and professional pitchers with a history of shoulder injury displayed similar findings.²⁰ In addition, baseball players with a UCL injury displayed higher GIRD when compared to a healthy control group.⁴ However, recent evidence suggests that GIRD may not differ in baseball players with UCL injury compared to healthy controls.⁵ The absence of differences between these groups in our study is consistent with this research. Although the lack of difference in GIRD between the UCL-injured and noninjured groups may seem counterintuitive, previous data on uninjured baseball players have demonstrated similar measurements of GIRD at the high school (15°),¹⁰ college (12.7°),¹ and professional (11.6°)²³ levels.

Limitations

It is possible that the UCL injury could have been partially responsible for changes in lower extremity balance and upper extremity ROM. The baseball players in this study with a UCL tear could have become less active or had less training, and therefore the observed deficits might have reflected a reduction in training. Due to the injury at the elbow, the baseball players may have decreased their volume of throwing and possibly lost some of their shoulder ROM in external rotation. Because this study was retrospective in nature, the differences seen between groups could be a result of the injury and not necessarily the cause.

However, despite being uncertain as to whether these deficits contributed to or were a result of the injury, the results suggest that baseball players with UCL tears should be tested for balance and that balance should be addressed if deficits are present.

In addition to balance, the Y Balance Test is reflective of lower extremity strength and neuromuscular control.^{9,15,18,19} The greater the distance a participant was able to reach, the greater the neuromuscular control of the lower extremity in question.¹⁵ Previous injury to the lower extremity could have predisposed these players to deficits in balance, strength, and/or neuromuscular control. However, out of the 30 participants in the UCL group, only 3 reported a past injury (within 2 years) to the lower extremity, including 2 anterior cruciate ligament reconstructions and 1 ankle fracture.

Another limitation in this study is the fact that the individuals involved in taking the shoulder ROM measurements were not blinded to group assignment of the participants. Because of the clinical nature of this study, participants were not referred to the clinic for study enrollment until a UCL tear was confirmed by the orthopaedic surgeon and by magnetic resonance imaging findings. The timing of participants presenting to the clinic for purposes of enrollment thus made it difficult for blinding to occur. As such, there was a potential source of bias for ROM measurements. We attempted to minimize this bias through reliability training and limiting discussion of the injury with those taking measurements.

CONCLUSION

THE RESULTS OF THIS STUDY ARE consistent with the clinical hypothesis of a potential association between impaired lower extremity balance and the development of a UCL tear in baseball players. This, in combination with deficits in shoulder TRM, may be an important factor for clinicians to consider when evaluating and treating players

with UCL tears. This preliminary work provides a framework for a more robust prospective study. ●

KEY POINTS

FINDINGS: Baseball players with a UCL tear, when compared to a matched control group, have decreased balance on both their stance and lead limbs. In addition, they also demonstrated greater deficits in TRM of their throwing arm.

IMPLICATIONS: Balance as well as shoulder ROM deficits should be considered in the prevention and treatment of UCL tears in baseball players.

CAUTION: The cross-sectional nature of the study precludes the conclusion of a direct cause-and-effect relationship.

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- Sports Physiotherapy Australia (SPA) Titled Members
- Physio Austria (PA) Sports Group
- Manual Therapy Association Belgium (MATHERA.BE)
- MaisFisio Consultoria e Desenvolvimento em Saúde
- Sociedad Nacional de Fisioterapia Esportiva (SONAFE)
- Sociedad Chilena de Kinesiología del Deporte (SOKIDE)
- Suomen Ortopedisien Manuaalisen Terapian Yhdistys ry (SOMTY)
- Orthopaedic Manual Therapy-France (OMT-France)
- German Federal Association of Manual Therapists (DFAMT)
- Association of Manipulative Physiotherapists of Greece (AMPG)
- Hellenic Scientific Society of Physiotherapy (HSSPT) Sports Injury Section
- Chartered Physiotherapists in Sports and Exercise Medicine (CPSEM) of the Irish Society of Chartered Physiotherapists (ISCP)
- Israeli Physiotherapy Society (IPTS)
- Gruppo di Terapi Manuale (GTM), a special interest group of Associazione Italiana Fisioterapisti (AIFI)
- Italian Sports Physical Therapy Association (GIS Sport-AIFI)
- Nederlandse Associatie Orthopedische Manuele Therapie (NAOMT)
- Sports Physiotherapy New Zealand (SPNZ)
- Norwegian Sport Physiotherapy Group of the Norwegian Physiotherapist Association
- Portuguese Sports Physiotherapy Group (PSPG) of the Portuguese Association of Physiotherapists
- Singapore Physiotherapy Association (SPA)
- Sports Medicine Association Singapore (SMAS)
- Orthopaedic Manipulative Physiotherapy Group (OMPTG) of the South African Society of Physiotherapy (SASP)
- Swiss Sports Physiotherapy Association (SSPA)
- Association of Turkish Sports Physiotherapists (ATSP)

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