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Adolescent female tennis players: Injury prevalence and prevention

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ABSTRACT

This literature review aimed to identify injury prevalence in adolescent female tennis players, and was conducted in accordance to the PRISMA guidelines (Shamseer et al., 2015). The lower extremity encountered the greatest number of injuries and musculotendinous injuries were the most common injury type. Injury prevalence and the anatomical location of injuries changed with chronological age. Acknowledging the results can help tailor strength and conditioning programmes to target the most prevalent injuries within each age group.

Key words: adolescent, female, injuries, tennis

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INTRODUCTION

Tennis is played by over 87 million people worldwide, making it one of the most popular global sports (ITF, 2019) with a growth in female participation. A literature review was undertaken to identify adolescent female specific injury prevalence and prevention, to help tailor coaching programmes accordingly. Many injury risk factors are unfortunately non-modifiable. It is important for coaches to be aware and take advantage of any risk factors that can be modified. The main injury prevention themes identified from the literature review are presented.

METHODS

The literature review used the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) (Figure 1) (Shamseer et al., 2015). Inclusion criteria involved analysing female tennis players between 10-19 years, published in English between 2009-August 2019 and an evaluation of injury outcomes (incidence, prevalence, type, location, severity). A systematic search was performed utilising Medline Ovid as the primary electronic database and replicated in: Web of Science, Sport Discus, PsychInfo, Scopus and CINAHL, with predefined the keywords and Boolean terms displayed in Table 1.

Table 1

Search Strategy Keywords and Boolean Terms.

Tennis
AND
Girl* OR Female*
AND
Adolescen*
AND
Athletic injur* OR Injur* OR Caus* OR Epidemiol* OR Etiolog* OR Aetiolog* OR Mechanism* OR Preval* OR Inciden* OR Occur* OR Propor* OR Distribut* OR Populat* OR Risk factor* OR Predispos* OR Acciden*

*Truncation: used to identify all possible endings of the key term; *AND:* searches for two terms and limits the search; *OR*: searches for two or more terms and widens the search

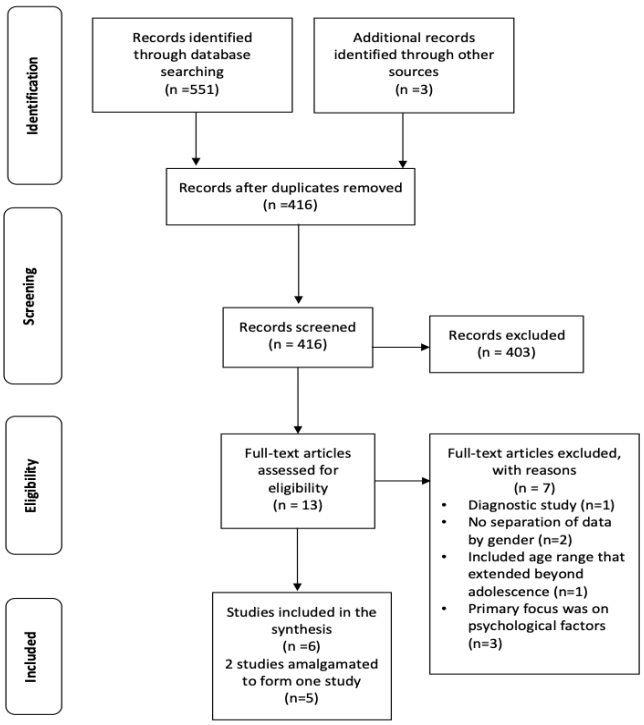

Figure 1. PRISMA flow chart of literature retrieval and selection.

DISCUSSION

Table 2
Characteristics of the reviewed studies.

Reference	Objective	Study Design	Study Population	Age of Participants (Years; Mean ± SD)	Injury Rates
Correia et al., 2016	Present a profile of medical complaints in ITF junior and Pro circuits tournaments	Prospective Cohort	N= 816 Male: 474 Female: 342	Male: 16.28 ± 0.56 Female: 15.72 ± 0.41 Total: 16.06 ± 0.47	Complaints (95% CI): Per match: 0.43 (0.29-0.56) Per 1000 games: 23.00 (15.72-30.28) Per 1000 hours: 337.59 (220.32-447.27)
Hjelm et al., 2010 Hjelm et al., 2012	Survey of injuries and risk factors in junior players from a Swedish local tennis club	Prospective Cohort	N= 55 Male: 35 Female: 20	Male: 16.10 ± 3.0 Female: 14.20 ± 2.0 Total: 15.40 ± 2.8	Incidence per 1000 hours (95% CI): 0.5 (0.26-0.67)
Gescheit et al., 2012	To profile multi-year injury incidence and severity trends in elite Junior tennis players from a national program	Prospective Cohort	N= 101 Male: 58 Female: 43	13-18	Incidence per 1000 hours (mean ±SD): 2.8 ± 0.0
Jayanthi et al., 2009	To Investigate the association between medical withdrawals and age, sex, match volume and match type	Retrospective Cross-sectional Cohort	N= 28,336 (exposures) Male: 14,108 Female: 14,105 Unavailable: 123	12-18	Medical withdrawals per 1000 match exposures: 14.0
Kovacs et al., 2014	To analyse a series of demographic, technique, injury and training related questions in competitive Junior tennis players	Prospective Cohort	N=832 Male: 356 Female: 476	10-17	/

INJURY CLASSIFICATION, TYPE AND ANATOMICAL DISTRIBUTION

Acute, traumatic injuries accounted for 34.5-44.4% and overuse injuries explained up to 55.6-65.5% of reported of female injuries. Overuse injuries were more frequent in the upper extremities (75%) than the trunk (67%) or lower extremity (39%). Injury severity analysis reveal nearly 50% of female injuries were classified as severe and required >28 days to return to participation (Correia et al., 2016; Hjelm et al., 2012). Musculotendinous complaints were the most common injury representing 71.3% of all female injuries, followed by joint injuries (17.2%). Ligaments were the most common injury within a joint, representing 12.1% of all injuries. The anatomical distribution of injuries revealed the lower extremity was the most prevalent injury site (41.4%), followed by the upper limb (29.9%) and the lower back/ trunk (22.2-25.90%). When analysed more acutely by sub-regions the lower back/lumbar spine accounted for 12.1% of trunk injuries, the shoulder recorded the highest number of injuries in the upper limb (16.7%) and the knee represented 14.9-18.5%, of total lower limb injuries in female adolescent players (Correia et al., 2016; Hjelm et al., 2012). The results of anatomical injury location is presented in Table 3.

AGE

Of particular interest to coaches is the reported increase in injury prevalence with chronological age (13-18 years) from 2.0 ± 0.2 to 2.9 ± 0.1 injuries per 1000 exposure hours (Gescheit et al., 2019). In adolescents 14 years and under the shoulder was the most dominant injury location, followed by the hip/groin (Gescheit et al., 2019; Kovacs et al., 2014). The knee was particularly prevalent in the under-16 category (Kovacs et al., 2014). However, a consistent observation between 14-18 years of age was the high prevalence lumbar spine injuries (Gescheit et al., 2019).

THE SHOULDER

A considerable proportion of injuries occur in a player's dominant shoulder (Fernandez-Fernandez et al., 2019) and are overuse in nature (Ellenbecker et al., 2009). The high level of repetition involved in tennis places the shoulder and particularly the rotator cuff at risk of sport specific muscular adaptations (i.e., a muscular imbalance and a loss of internal rotation ROM) (Fernandez-Fernandez et al., 2019). The research suggests that from an early age players are developing a high incidence of shoulder related injuries. Therefore, should be a prevention focus as early as possible in players.

LUMBAR SPINE

The spine is at considerable risk of injury, particularly if the correct technique is not executed (Salzmann et al., 2018). The serve is frequently associated with the development of lower back pain in adolescent players, due to the high-level of muscular activation and mechanical loading. The kick serve, commonly introduced between 12-15 years of age (Campbell

Table 3
Injury Anatomical Distribution.

	Correia et al., 2016	Hjelm et al., 2010; Hjelm et al., 2012		Gescheit et al., 2019	Kovacs et al., 2014
	Number of complaints/Total complaints (%)	Incidence per 1000 hours (95% CI)	Incidence per 1000 hours (Mean ± SD)	Percentage of Injuries (%)	Incidence per 1000 hours (Mean ± SD)
Foot	6/174 (3.4)		1.9 ± 0.4	2 – 8	1.9 ± 0.4
Ankle	9/174 (5.2)		2.3 ± 0.3	9 – 17	2.3 ± 0.3
Knee	26/174 (14.9)		2.0 ± 0.2	8 – 22	2.0 ± 0.2
Thigh	26/174 (14.9)		1.6 ± 0.1	2 – 5	1.6 ± 0.1
Hip/Groin	0		1.4 ± 0.2	0 – 5	1.4 ± 0.2
Lower back	21/174 (12.1)		3.9 ± 0.2	4 – 17	3.9 ± 0.2
Shoulder	29/174 (16.7)		2.6 ± 0.2	11 – 25	2.6 ± 0.2
Elbow	8/174(4.6)		1.7 ± 0.3	3 – 4	1.7 ± 0.3
Wrist and Hand	8/174 (4.6)		2.4 ± 0.2	9 – 10	2.4 ± 0.2
Head/Neck	5/174 (2.9)		0.5 ± 0.1	0 – 1	0.5 ± 0.1
Other	0		0	10 - 17	0
Upper extremity	52/174 (29.9)	0.1 (0.03-0.25)	6 /27 (22.2)		
Lower extremity	73 /174 (41.4)	0.3 (0.16-0.50)	14 /27 (51.9)		
Lower back/Trunk	45 /174(25.9)	0.2 (0.04-0.29)	7/27 (25.6)		

et al., 2013), potentially contributes to the high incidence of lumbar spine injuries. A commonly observed predisposing factor is muscular imbalance. Injury prevention should focus on extensive core stability, involving both flexor and extensor muscular development. Rotational exercises are required to build resilience to the high repetitive demands (Ellenbecker et al., 2009).

HIP AND GROIN

The loading, multidirectional movements and extreme range of motion that are demanded of the hip during tennis, place the joint and the surrounding soft tissue structures at risk of injury (Safran, 2014). The hip joint muscles play a vital role in the transfer of forces through the kinetic chain. Hip muscle strength can impact the load through the joint, altering its function, impacting injury risk, not only to the hip but also the lower back and knee (Ellenbecker et al., 2009).

KNEE

A high prevalence of knee injuries was observed particularly in females of 16 years of age. Many knee injuries share similar risk factors that can be targeted. Both ligaments injuries and patellofemoral pain are often associated with muscle weakness, and /or imbalance and limited flexibility in the knee and pelvic-femoral region. A decreased level of neuromuscular control around the knee has been reported in female athletes during maturational growth (Hewett et al., 2004), potentially contributing to the increased level of knee injuries witnessed.

Integrating core stability training into an athletes training has been demonstrated to be crucial in preventing and reducing injuries, particularly to the lower limb. It has been suggested that the core is the foundation of the kinetic chain and facilitates the transfer of energy from the lower to the upper extremities (Huxel-Bliven & Anderson, 2013) which is pivotal in tennis and for enhancing performance. The exercises below focus on some core exercises that provide stability for the tennis player (Huxel-Bliven & Anderson, 2013). The subsequent region specific exercises, focus on the most prevalent female adolescent injuries identified from the literature review. These exercises may be useful to incorporate into an adolescent female's injury prevention strength and conditioning routine.

Core stabilisation exercise:

Bridge:

- Trains the back, abdominal and gluteal muscles simultaneously
- Lie on your back with knees flexed to 90 °
- Push pelvis up
- Ensure the pelvis and torso are in one line

Figure 2. Brige.

Dead bugs:

- On your back place hips and knee at 90°
- Lower opposite arm and leg
- Keep the small of your back pushed into the ground by activating your core and do not compensate by arching the back
- Develops lumbopelvic stability

Figure 3. Dead bugs.

Superman exercise:

- In four point kneeling with a neutral spine
- Extend opposite arm and leg
- Engage core muscles and do not hyperextend their spine when extending the leg
- Targets the gluteal, hamstrings, external obliques and back muscles

Figure 4. Superman exercise.

Side Plank:

- Lying on side
- Lift up into a side plank with feet stacked or one foot in front of the other
- Ensure a straight line from feet to shoulders
- This targets the Abdominal muscles (external obliques, rectus abdominus), back muscles and gluteus medius

Figure 5. Side Plank.

Many exercises focus on one particular region but can be beneficial for other anatomical locations due to the pivotal role of the whole kinetic chain in tennis. Below are some region specific exercises.

Shoulder Emphasis:

- Lawnmower exercises: initiating the exercise with the lower extremities increases scapular muscle activation and recruitment (Funk et al., 2018)
- The step-up with resistance band: requires hip extension and this reinforces gluteal and sequential activation throughout the kinetic chain. The resistance band also reinforces rotator cuff muscle activation (Funk et al., 2018).
- Shoulder external rotation with resistance band: providing support to the working limb will also ensure selective recruitment of the rotator cuff muscles (Funk et al., 2018)

Lower extremity

- Clams and Reverse Clams: to target hip Internal and external rotation, perform on both sides to work on achieving symmetrical hip rotational strength in the lower limbs (Ellenbecker & Pluim, 2009).
- Multidirectional lunge: To strengthen hip, knee, ankle and core stability while also challenging dynamic balance, required for multidirectional movements in tennis (Samson et al., 2007; Huxel-Bliven & Anderson, 2013)
- Single leg squat: Focuses on improving neuromuscular control particularly of the knee (Hewett et al., 2004), targets the gluteal muscles, while also challenging core stability. Poor gluteal strength has also been linked with reduced shoulder performance in overhead sports (Funk et al., 2018).

CONCLUSION

Adolescent female players need to be provided with core strength and conditioning and also more specific strength and conditioning that is tailored to prevent the most prevalent age related injuries that have been reported in the literature. Further research focusing on adolescent female injury is recommended, as the current paucity of research impacts on evidence based targeted injury prevention programmes for this group of tennis players.

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