Predictors of Overuse Running Related Musculoskeletal Injuries

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Abstract: Background: Running is one of the most widespread activities during which overuse injuries of the lower extremity occur. Long-distance running is very popular among participants of recreational sports. **Objectives:** The purpose of this study was to identify changes in degree of Q-angle, degree of foot pronation and hamstring flexibility as a significant predictor of overuse running related musculoskeletal injuries in distance runners as a result of their participation in training and competitions. **Study design:** prospective cohort study. **Methods:** Thirty athletes from National Egyptian team participated in this study. Data were collected and assessed from all athletes regarding intrinsic risk factors (gender, age, weight, height, previous injury, anatomical risk factors) and extrinsic risk factors (running experience, intensity, events and exposure/week), as a predictors for running related musculoskeletal injuries. **The outcome measures**: Q angle, foot pronation and hamstring flexibility were assessed using Auto cad system, navicular drop test and active knee extension test respectively, data were collected regarding intrinsic and extrinsic risk factors. **Results:** There was no statistical significant difference between injured and non-injured groups in gender, age, weight, height, previous injury, running experience, intensity, events and exposure/week. There was statistical significant difference between injured and non-injured groups in Q angle as the main predictor for overall running related injuries, and left foot pronation as the main predictor for leg injuries. There was no statistical significant difference between injured and non-injured groups in hamstring flexibility as a predictor for overall injuries or hamstring injuries. **Conclusion:** Q angle and foot pronation is a predictors for running related musculoskeletal injuries.
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1. Introduction

Various epidemiological studies of recreational and competitive runners (**Hreljac.2004**) have estimated that up to 70% of runners sustain overuse injuries during 1-year period. Running injuries ranged from 19.4 to 79.3% **(Van Gent et al., 2007).** There is no standard definition of an overuse running injury, but several authors (**Koplan et al., 1982; Lysholm and Wiklander, 1987; Macera et al., 1989; Hreljac et al., 2000)** have defined it as a musculoskeletal ailment attributed to running that causes a restriction of running speed, distance, duration, or frequency for a least one week.

Overuse injuries of the musculoskeletal system generally occur when a structure is exposed to a large number of repetitive forces, each below the acute injury threshold of the structure, producing a combined fatigue effect over a period of time beyond the capabilities of the specific structure (**Hreljac et al., 2000**).

Most running-related injuries occur in the lower extremities **(Chang et al., 2012; Lopes et al., 2012; Van Hespen et al., 2012; Van Poppel et al., 2016).** The most common anatomical site of running injuries is the knee **(Van Middelkoop et al., 2008a, b; Van Poppel et al., 2016)**.

The various purported risk factors for running injuries are commonly divided into intrinsic and extrinsic risk factors. Intrinsic risk factors include mostly anatomic and other variables that are innate to the individual, such as gender, age, height, weight, personality type (e.g., aggressive, passive), and anatomic factors such as femoral anteversion, genu varus or valgus, pes planus or cavus, bone density, muscular flexibility, and leg-length discrepancies. Extrinsic risk factors include training variables such as mileage, hill running, pace, interval training, equipment (shoes, shoe inserts), and training surfaces **(Wen.2007**).

Anatomical variables such as tibia varum, rear foot varus, and leg length discrepancies could be grouped together as lower extremity alignment abnormalities. These factors, and other problems related to alignment of the body have been reported to be associated with overuse running injuries by some authors **(James et al., 1978; Stanish, 1984)**, although others **(Montgomery et al., 1989; Rudzki, 1997**; **Walter et al., 1989; Wen et al., 1997.**) did not find lower extremity alignment abnormalities to be associated with an increased risk of overuse injuries in runners.

The Q-angle provides an estimate of the vector force between the quadriceps muscle and patellar tendon. Theoretically, a large Q-angle increases the lateral pull on the patella against the lateral femoral condyle, thus contributing to patllar subluxation and other patellofemoral pain disorders. Results of prior research have been mixed regarding the Q-angle as a predictor of patellofemoral pain and other running injuries among adult competitive and recreational runners, lower extremity injuries in military training, and overuse injuries in other sport populations. **(Rauh et al., 2007).**

2. Methodology

This study was conducted in the Olympic centre for training national teams and Army club. In a period from February to August 2018. Thirty athletes 21 males and 9 females participated in this study. Degree of Q-angle, foot pronation and hamstring flexibility were measured for each athlete to predict relation between theses measurements and overuse running related musculoskeletal injuries in distance runners.

The patients were chosen under the following criteria:

- All athletes were from the National Egyptian team.
- The athletes age ranged between 17-38 years old participated in the current study.
- Both genders were included.
- All athletes were selected from medium and long-distance runners (800 meter to 21 kilometres).
- All athletes had an average running period (6 days per week and 3 hours per day).

The current study excluded patients who have:

- Athletes with any musculoskeletal disorders.
- Athletes with neurological affection e.g. (Erbs palsy).

The procedures of the current study were:

- Data were collected from each subject including the age, sex, BMI, training intensity, running experience, running exposure h/week, running events and type of running surface.
- The site of a previous musculoskeletal injury of the lower extremity and lower back was established by using pictures of anatomical sites.
- Injuries were self-reported during the season and each time that an injury was reported were administered during the 6 months.
- Participants were also asked whether they failed to train for at least one session due to the presence of any RRI (running related injuries) during the period, In this case, the participant was asked to report the symptoms/diagnosis and the anatomical region that was injured.

Measurements:

- Degree of Q angle was assessed for all athletes at the beginning of the season, the Q-angles of both lower extremities for all runners were measured using a marker dots and AutoCAD system.
- The approach selected for measuring frontal plane limb alignment uses three bone landmarks of the anterior superior iliac spine, mid patella and tibial tuberosity to derive the Q angle measurement. The Q angle was measured as the acute angle formed between lines from the anterior superior iliac spine to the center of the patella, and from the center of the patella to the center of the tibial tubercle.
- The angular relationship were derived between these anatomic axes (anterior superior iliac spine, mid patella and tibial tuberosity) and the angular relationships. Finally, intersecting lines were drawn using AutoCAD_ software between the three bony land marks. The patterns were exported from AutoCAD_ as digital images for computer-assisted measurements of alignment.
- At the beginning of the season, the hamstring flexibility of both lower extremities for all runners were measured using wooden box and inclinometer.
- Subjects were positioned in supine without a pillow underneath their heads, with the contralateral lower extremity in 0_ of hip flexion, maintained by a Velcro strap secured to the table. The participant's ipsilateral thigh was flexed to 90_, with the right ischial tuberosity placed against the box. The ipsilateral mid-thigh was then strapped to the box to maintain this position. Subjects were then instructed to slowly extend their right knee until they felt the first stretch sensation, with the foot relaxed in plantar flexion. The use of the first stretch sensation as the point of completion of the active knee extension test was used using inclinometer to measure degree of hamstring flexibility.
- At the beginning of the season, the navicular drop of both feet were measured for each runner. A fine-tipped marker was used to mark the most prominent point of the navicular tubercle on the runner's feet in a sitting position. A ruler was placed next to the medial foot perpendicular to the floor and was read (mm) at the height of the navicular tubercle in sitting position, then the ruler again read at the height of the navicular tubercle in complete weight bearing (standing),. The 2 measurements were recorded, and the difference value was documented as navicular drop.

3. Results

There was no statistical significant difference between the two groups (injured and non-injured as regard age (Z= -0.320; p= 0.749), weight (Z= -0.541; p= 0.589), height (Z= -0.885; p= 0.376) and BMI (Z= -0.711; p= 0.477) as show in table (1). As regards gender distribution in the two groups, the number of females and males in non-injured group were 2 (28.6%) and 5 (71.4%), respectively while in injured group they were 7 (30.4%) and 16 (69.6%), respectively.

Table (1): Demographic features (general characteristics) of the two studied groups.

	Not injured (n= 7)	Injured (n= 23)	Z test	P value
Age (yrs.)	26.00 ± 9.42	24.13 ± 6.66	-0.320	0.749
Sex				
Female	2 (28.6%)	7 (30.4%)	χ^2= 0.009	0.925
Male	5 (71.4%)	16 (69.6%)		
Weight (kg.)	61.14 ± 6.04	60.07 ± 8.29	-0.541	0.589
Height (m.)	1.72 ± 0.08	1.68 ± 0.10	-0.885	0.376
BMI (kg/m^2)	20.68 ± 1.11	21.12 ± 1.83	-0.711	0.477
Previous injuries (yrs.)	4 (57.1%)	15 (65.2%)	χ^2= 0.151	0.698

As regards previous injuries in the two groups, the number of previous injuries in non-injured group were 4 (57.1%) while in injured group they were 15 (65.2%). They were statistically comparable (Chi square value= 0.151 and p= 0.698) as show in table (1).

There was no statistical significant difference in the mean value of training hours between non-injured group (2.43 ± 0.53) and injured group (2.76 ± 0.90) (Z= -0.728; p= 0.466) as shown in (Table 2).

As regards running events in the two groups, in non-injured group the number of runners who run ≤ 3 kms were 4 (57.1%) and those who run > 3 kms were 3 (42.9%) while in injured group they were 11 (47.8%) and 12 (52.2%), respectively. They were statistically comparable (Chi square value= 0.186 and p= 0.666) as shown in (Table2).

Also there was no statistical significant difference in the mean value of running experience between non-injured group (9.86 ± 5.70) and injured group (9.65 ± 6.11) (Z= -0.147; p= 0.883) as shown in (Table 2).

As regards type of surface, in non-injured group, the number of runners on asphalt were 1 (14.3%), on track were 5 (71.4%) and both asphalt and track were 1 (14.3%). While in injured group, the number of runners on asphalt, track and both asphalt and track were 6 (26.1%), 7 (30.4%) and 10 (43.5%), respectively. There was no statistical significant difference between the two groups as regards type of surface (Chi square test= 3.822; p= 0.148) as shown in table (2).

Table 2: Running characteristics and exposure in the two studied groups.

	Non-injured (n= 7)	Injured (n= 23)	Z test	P value
Events				
≤ 3 km.	4 (57.1%)	11 (47.8%)	χ^2= 0.186	0.666
> 3 km.	3 (42.9%)	12 (52.2%)		
Training hours	2.43 ± 0.53	2.76 ± 0.90	-0.728	0.466
Type of surface				
Asphalt	1 (14.3%)	6 (26.1%)		
Track	5 (71.4%)	7 (30.4%)	χ^2= 3.822	0.148
Both	1 (14.3%)	10 (43.5%)		
Running experience	9.86 ± 5.70	9.65 ± 6.11	-0.147	0.883

Q angle of the two studied groups.

A. Q angle of the dominant side

There was no statistical significant difference in the value of the Q angle of the dominant side between non-injured group (15.71 ± 2.56) and injured group (16.09 ± 2.75) (Z= -0.346; p= 0.729) as shown in table (3).

In non-injured group 4 (57.1%) out of the 7 runners had abnormal Q angle of the dominant side while in injured group they were 16 (69.6%) out of 23. There were no statistical significant difference between the two groups (Chi square value= 0.373 and p= 0.542) as shown in table (3).

B. Q angle of the non-dominant side

There was no statistical significant difference in the value of Q angle of the non-dominant side between non-injured group (15.36 ± 2.66) and injured group (16.59 ± 2.93) (Z= -1.037; p= 0.300) as shown in table (3).

In non-injured group the number of runners who had abnormal Q angle of the non-dominant side were 2 (28.6%) out of 7 while in injured group they were 18 (78.3%) out of 23. There was statistical significant difference between the two groups (Chi square value= 5.963 and p 0.015 as shown in table (3).

Univariate analysis of variables for overall running-related injuries

All studied variables were not predictors for overall running-related injuries except Q angles of the dominant and non-dominant sides were considered predictors for overall running-related injuries (odds ratio= 0.092; 95% CI= 0.010-0.843) (p= 0.035) and (odds ratio= 5.051; 95% CI= 1.027-24.842) (p= 0.046), respectively as shown in table (4).

Hamstrings flexibility in the two studied groups.

A. Hamstrings flexibility of the dominant side

There was no statistical significant difference in the value of hamstring flexibility in the dominant side between non-injured group (23.33 ± 16.57) and injured group (28.64 ± 12.15) (Z= -0.858; p= 0.391) as shown in table (5).

In non-injured group 5 (71.4%) out of the 7 runners had abnormal hamstring flexibility in the dominant side (> 15) while in injured group they were 19 (82.6%) out of 23. There was not statistical significant difference between the two groups (Chi square value= 0.419 and p= 0.517) as shown in table (5).

Table 3: Q angle of the two studied groups.

	Non-injured (n= 7)	Injured (n= 23)	Z test	P value
Q angle of the dominant side	15.71 ± 2.56	16.09 ± 2.75	-0.346	0.729 (NS)
Normal	3 (42.9%)	7 (30.4%)	χ^2= 0.373	0.542 (NS)
Abnormal	4 (57.1%)	16 (69.6%)		
Q angle of the Non-dominant side	15.36 ± 2.66	16.59 ± 2.93	-1.037	0.300 (NS)
Normal	5 (71.4%)	5 (21.7%)	χ^2= 5.963	0.015 (S)
Abnormal	2 (28.6%)	18 (78.3%)		

Table 4: Univariate analysis of variables for overall running-related injuries.

	B	P value	Odds ratio	95.0% C.I.	
				Lower	Upper
Age	-0.361	0.064	0.697	0.476	1.022
BMI	0.303	0.663	1.354	0.346	5.307
Events	1.861	0.345	6.430	0.135	306.981
Q angle of the dominant side	-2.383	0.035*	0.092	0.010	0.843
Q angle of the non-dominant side	1.620	0.046*	5.051	1.027	24.842
Hamstring flexibility of the dominant side	0.344	0.161	1.410	0.872	2.281
Hamstring flexibility of the non-dominant side	-0.281	0.202	0.755	0.490	1.163
Navicular drop of the dominant side	11.759	0.115	1278.31	0.057	2854120.39
Navicular drop of the non-dominant side	-7.227	0.165	0.001	0.000	19.681
Previous injuries	2.457	0.156	11.672	0.392	347.130

B. Hamstrings flexibility of the non-dominant side

There was no statistical significant difference in the value of hamstring flexibility in the non-dominant side between on-injured group (22.76 ± 15.62) and injured group (28.90 ± 12.59) (Z= -1.129; p= 0.259) as shown in table (5).

In non-injured group the number of runners who had abnormal hamstring flexibility in the non-dominant side between were 4(57.1%) out of the 7 runners while in injured group they were 19 (82.6%)

out of 23. There was not statistical significant difference between the two groups (Chi square value= 1.946 and p= 0.163) as shown in table (5).

Table 5: Hamstrings flexibility of the two studied groups

	Non-injured (n= 7)	Injured (n= 23)	Z test	P value
Hamstrings flexibility of the dominant side	23.33 ± 16.57	28.64 ± 12.15	-0.858	0.391 (NS)
(normal) (abnormal)	2 (28.6%) 5 (71.4%)	4 (17.4%) 19 (82.6%)	χ^2= 0.419	0.517 (NS)
Hamstrings flexibility of the Non-dominant side	22.76 ± 15.62	28.90 ± 12.59	-1.129	0.259 (NS)
(normal) (abnormal)	3 (42.9%) 4 (57.1%)	4 (17.4%) 19 (82.6%)	χ^2= 1.946	0.163 (NS)

Navicular drop of the two studied groups

A. Navicular drop of the dominant side

There was no statistical significant difference in the value of navicular drop of the dominant side between non-injured group (0.80 ± 0.29) and injured group (1.04 ± 0.39) (Z= -1.455; p= 0.146) as shown in table (6).

In non-injured group 3 (42.9%) out of the 7 runners had abnormal navicular drop of the dominant side> 0.8 while in injured group they were 14 (60.9%) out of 23. There were not statistical significant difference between the two groups (Chi square value= 0.709 and p= 0.400) as shown in table (6).

B. Navicular drop of the non- dominant side

There was no statistical significant difference in the value of navicular drop of the non-dominant side between non-injured group (0.87 ± 0.30) and injured group (1.00 ± 0.43) (Z= -0.616; p= 0.538) as shown in table (6).

In non-injured group 3 (42.9%) out of the 7 runners who had abnormal navicular drop of the non-dominant side were > 0.8 while in injured group they were 14 (60.9%) out of 23. There was statistical non-significant difference between the two groups (Chi square value 0.709 and p 0.400 as shown in table (6).

Table 6: Navicular drop of the two studied groups.

	Non-injured (n= 7)	Injured (n= 23)	Z test	P value
Navicular drop of the dominant side	0.80 ± 0.29	1.04 ± 0.39	-1.455	0.146 (NS)
(normal) (abnormal)	4 (57.1%) 3 (42.9%)	9 (39.1%) 14 (60.9%)	χ^2= 0.709	0.400 (NS)
Navicular drop of the non-dominant side	0.87 ± 0.30	1.00 ± 0.43	-0.616	0.538 (NS)
(normal) (abnormal)	4 (57.1%) 3 (42.9%)	9 (39.1%) 14 (60.9%)	χ^2= 0.709	0.400 (NS)

Univariate analysis of leg injury and navicular drop

The navicular drop of the dominant side was not a predictor for leg injury (odds ratio= 24.044; 95% CI= 0.357-1619.92; p= 0.139). That to say every one unit increase in the navicular drop of the dominant side lead to increase in leg injuries odds ratio by 24.044; 95% CI= 0.357-1619.92; p= 0.139) as shown in table (7).

In the other hand, the navicular drop of the non-dominant side was a predictor for leg injury (odds ratio= 0.007; 95% CI= 0.000-0.911; p= 0.046). That to say every one unit increase in the navicular drop of the non-dominant side lead to increase in leg injuries odds ratio by 0.007; 95% CI= 0.000-0.911; p= 0.046) as shown in table (7).

Table 7: Univariate analysis of navicular drop variables for leg injuries.

	B	P value	Odds ratio	95.0% C.I.	
				Lower	Upper
Navicular drop of the dominant side	3.180	0.139	24.044	0.357	1619.92
Navicular drop of the non-dominant side	-5.018	0.046*	0.007	0.000	0.911

4. Discussion

The current study was conducted to predict overuse running related musculoskeletal injuries in medium and long-distance running, those who are in the National Egyptian team.

The aim of this study was to determine the incidence and characteristics of running related injuries and to identify specific predictors for running related injuries among medium and long distance runners.

The results of this study revealed that there was no statistical significance difference regarding age, BMI and gender between injured and non-injured group. Moreover, training hours, running type (events), running surface and running experience also showed no statistical significance difference between injured and non-injured groups.

While in anatomic risk factors resultsreveled regarding hamstring flexibility no statistical significance difference between normal and abnormal values in injured and non-injured groups.

In overall running related musculoskeletal injuries Q angle was the main predictor for injuries and in leg injuries excessive foot pronation was the main predictor which showed statistical significant difference, while all other intrinsic and extrinsic variables were statistically non-significant regarding overall running related injuries.

The results of our study came into agreement with previous studies that higher quadriceps angle of the knee (Q angle) was associated with running injuries in two **(Rauh et al.,2005; Rauh et al.,2007)** of three studies that analysed this factor.

For further support of the current study one biomechanical (alignment) risk factor was found in more than one study, Higher Q-angle factor was significantly associated with running-related injury. Theoretically, a greater Q angle is related to the increase of the lateral pull on the patella against the lateral femoral condyle, which contributes to patellar subluxation and other patellofemoral disorders (**Rauh et al.,2007**).

It appears intuitive that greater lower extremity flexibility would lower joint stress and diminish the risk of overuse running injuries **(Buist et al.,2010);** however, little supportive scientific evidence exists. The frequency of stretching provides no information on quality and does not directly measure flexibility. Also contributing to the lack of relevant data is the lack ofgold standard measures of flexibility. **(Messier and Pittala, 1988; Warren,1984).**

Some evidence exists that greater hamstring flexibility lowers the risk of injury**. (Hreljac et al., 2000)**. previous retrospective studies showed that flexibility was not a risk factor for knee pain**, (Duffey et al., 2000; Messier et al., 1991)** iliotibial band friction syndrome, (**Messier et al., 1995)** medial tibial stress syndrome,, **(Messier and Pittala, 1988)** or Achilles tendinitis**. (Mccrory et al., 1999).**

Similarly, there were no differences in quadriceps, hamstring, or ankle dorsiflexor and plantar flexor flexibility between our injured and uninjured groups **(Messier et al.,2018).**

In a previous study, navicular drop (foot pronation) was not identified as a risk factor for running-related injuries. **Buist et al**. and **Bennet et al**. found that women with a greater navicular drop were more prone to running-related injuries (**Buist et al.,2010; Bennet et al.,2012).**

In the current study navicular drop of the non-dominant side was a predictor for leg injuries and this may be due to altered biomechanics of the left (non-dominat) lower leg due to change in left Q angle (non-dominant) which was a significant predictor for running related injuries, further studies needs to be investigated to detect relationship between alteration in anatomical alignment of the knee and navicular drop on the ipsilateral side.

The discrepancy between findings of the current and those of these two studies might be due to the greater diversity of the runners in the current study compared with the runners in the study of **Buist et al**. (only novice runners) and **Bennet et al**. (high school cross-country athletes). (**Buist et al., 2010; Bennet et al., 2012).**

Previous study came into agreement with the current study was that an increased eversion increased the risk for exercise related lower leg pain (ERLLP), which can be functionally linked with both theories. Several kinematic and plantar pressure parameters indicate this increased loading underneath the medial side of the foot and decreased loading underneath the lateral side in subjects with subsequent ERLLP **(Willems et al., 2006).**

Conclusions

In view of the results of this study it can be concluded that Q angle is the main predictor of running related musculoskeletal injuries in long distance runners and navicular drop is the main predictor for leg injuries in runners.

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