Study of Prevalence of Neuromuscular Dysfunctions Especially Trunk Dysfunction among the Athletic Population of Rocket, Team and Water Sports

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Abstract

**Background:** The high prevalence of injury in sports necessitates the use of screening tests and injury prevention programs. Dysfunctions in the neuromuscular control of the trunk or TD (Trunk Dysfunction) are directly related to athletic performance and injury. The present study aims to study the prevalence of neuromuscular dysfunctions especially TD among the athletic population of rocket, team and water sports.

**Results:** For data analysis, it's used the analysis of variance of (ANOVA) and also the Chi-square tests. The ANOVA test did not show a significant difference between tuck jump test scores among the three sports; the Chi-square test, on the other hand, demonstrated people with and without TD. The number of people with TD was 12 (40%) in table tennis, 6 (20%) in cycling, and 9 (30%) in swimming respectively.

Conclusions: It can be concluded that the most and the least people with TD were table tennis and cycling, respectively. According to the direct relationship between TD and sports injury, it's possible to reduce the risk of injury by an accurate and timely screening and assessing of TD in future athletes, by this, it seems that the quality level and the implementation strategies of techniques, the skills and the activities of athletes can be improved.

**Background**

Table tennis, cycling, and swimming are sports that have repetitive movements and sustained postures but have different functional or movement patterns. Table tennis is one of the most popular, competitive, and recreational groups of sport in the world (1). This sport is fast and exciting and has several vital elements that the sums of their interactions show the unique position of this sport among racquet sports (1). Most injuries are related to muscle tissue that affects the lower back and shoulder girdle. Other affected parts of the body are the ankle and the spine (2). Cycling is also a popular sport around the world that has been shown to not only improve fitness and health but also help with rehabilitation diets because it has less impact on the joints compared to other activities such as walking and running (2). Despite these benefits, cycling can also lead to overuse, fatigue, and acute injuries (3). Finally, swimming also is one of the unique sports that combine upper and lower extremity strength training with cardiovascular training in a non-weight-bearing environment (3). Four competing swimming groups are recognized: freestyle, backstroke, breaststroke, and butterfly stroke. Repetitive movements that occur in swimming can expose swimmers to musculoskeletal injuries, especially in the upper extremity, knees, and spine (4).

Core stability is defined by controlling the movement and muscle capacity of the lumbopelvic-hip girdle (5). Core stability plays a very important role in preventing sports injuries (6). Maintaining the postural alignment and balance of the body during functional activities is one of the tasks of the core that prevents faulty patterns (7). Limitations on the strength, endurance, and stability of the deep muscles cause faulty upper and lower extremity movement techniques, leading the athlete to injury (8). Excessive
use of a certain group of muscles in a limited range of motion leads to muscle imbalance and ultimately undesirable changes in postural malalignment and neuromuscular dysfunctions (9). Impairment and dysfunction of the core stability during exercise leads to increased uncontrolled movements of the trunk. Any asymmetry in the activity of the proximal muscles of the knee can affect the position of the knee joint during landing or shearing movements (10). Decreased activity of the thigh and trunk stabilizer muscles leads to malalignment of the lower extremity, which in turn reduces the weight-bearing capacity of the knee joint (10). One of these dysfunctions in neuromuscular control is TD (Trunk Dysfunction) or core stability dysfunction. TD is defined as insufficient control and coordination to resist trunk inertia during landing (10).

Nowadays, due to the increasing incidence of sports injuries, pre-season screening of athletes in competitive sports is common today. Screening is done to prevent injury as well as to improve implementation strategies. Tuck Jump is a clinical and functional test designed to identify the jumping and landing errors of the lower extremity during plyometric activities and to identify the neuromuscular control dysfunction (11). This test can show us neuromuscular control dysfunctions such as TD, ligament dominance, leg dominance, and quadriceps dominance (11). Also, due to the relationship between the tuck jump test and ACL (Anterior Cruciate Ligament) injury, this test can be used to screen and assess athletes and protect them from future risk factors for injury (12). Most of the movement patterns of table tennis, cycling, and swimming (breaststroke and butterfly stroke swimmers) are approximately rotatory, flexory, and extensory movements, respectively. According to the researcher, the different movement patterns of the trunk in these three groups of elite athletes of table tennis, cycling, and swimming in the long-term, can cause dysfunctions, common musculoskeletal imbalances, especially TD.

It seems that TD has caused many changes in society recently and nowadays there are fewer studies on the prevalence of TD, especially among the three different sports that have different techniques, natures, and movement patterns to investigate which sport has the most TD related to its specific movement pattern.

Worth mentioning that most of the researches have traditionally been done on static postural changes in athletes, such as kyphosis and lordosis in cycling, but little research has been done to screen and assess the dynamic postural changes such as trunk oscillation, dynamic valgus and so forth among athletes. In this research, we do this by the Tuck jump test and screen their TD and also highlight the importance of the trunk in sports for the athletes and the sports community. Also express that by a timely screening of athletes' TD, the quality level and the implementation strategies of techniques, the skills and activities can be improved and injuries will be reduced. The researcher believes that the current results of this study will reduce future injuries and costs for surgery and so on.

Thus, the first aim of the researcher is to study of prevalence of neuromuscular dysfunctions especially TD among the athletic population of rocket, team and water sports. The second aim of the researcher is
that whether there is a significant difference between tuck jump test scores and TD among athletes in three different sports of table tennis, cycling, and swimming?

**Methods**

The method of this research was in a quasi-experimental manner. In this research, out of 120 athletes, 30 of them did not meet one of the following criteria and as a result, were eliminated from the test. The rest population of the research consisted of 90 youth elite (at the provincial elite level) athletes with 15 to 17-year-old such as table tennis players (30 individuals), cycling (30 individuals), and swimming (breaststroke and butterfly stroke swimmers, 30 individuals) from Tabriz city. Inclusion criteria were having an age range of 15 to 17 years, having at least 4 years of playing experience or regular training 3 times a week, having a male gender, not having cruciate ligament injuries, not having any deformities, and finally filling out the consent form. Then, from each sport, 30 subjects were selected in a purposefully available manner. Necessary information and knowledge about how to perform the research steps orally and in writing and scoring errors related to the tuck jump test were given to the subjects. As mentioned above, before starting the research, all the subjects signed the consent form to participate in the research tests, and then during a session, the subjects were explained how to perform the tests. As it is worth mentioning, the subjects did not have any intense physical activity 48 hours before the test and consumed their last meal 3 hours before the test. The subjects were at the level of the provincial elite and did not have any injuries so they were physically healthy and had no history of low-back pain or cruciate ligament injury.

Subjects were assessed using the tuck jump test (specificity: 67% and sensitivity: 84%) (Inter-rater reliability 0.93 and intra-rater reliability 0.87) (13) and also each person was assessed 3 times with a time interval of 15 seconds between them and the average score of athletes was recorded to identify people with and without neuromuscular dysfunction, especially TD. To perform the test, the athletes should stand with their legs spread shoulder-width apart and begin to jump vertically, raise their knees as high as possible. At the peak jump, the thighs should be parallel with the ground (14). When landing, the athletes had to start the next jump. This test was run for 10 seconds. Two video cameras also were used to improve the authenticity of the assessment. The cameras were adjusted according to the height of the subjects and parallel to the sagittal and frontal planes relative to the subjects and at a distance of 3 meters from them so that the image could be provided to the researcher in a magnified image for analysis. After the test, Kenova software was used to check the jump sequences (Fig. 1). A person who was unable to land at the start of his jump and unable to keep his thighs parallel with the ground at the peak of his jump, also if his jumps were interrupted for 10 seconds, considered a person with TD (14). To ensure the presence of dysfunctions in athletes, before conducting research, a pilot project was performed and the presence of dysfunctions in them was confirmed. The groups were matched according to age, sports history, and anthropometry characteristics.

Finally, the test results were compared among elite athletes in table tennis, cycling, and swimming. Descriptive and inferential statistical methods were used to analyze the collected data and the
Kolmogorov-Smirnov test and Leven test were used to analyze the normality of data distribution. ANOVA (Analysis of Variance) test was used to compare the mean of research variables and to analyze the variances in each group to compare the scores of the tuck jump test. On the other hand, the Chi-square test at the significance level of 0/05 was used to compare the prevalence of TD and also to determine the percentage and number of people with and without TD. All statistical analyses were performed using SPSS (Statistical Package for Social Sciences) 24 software.

**Results**

Table 1: Descriptive statistics of research variables (Subject’s demographic information)

| Variables             | Group        | SD±Mean | Significance level |
|-----------------------|--------------|---------|--------------------|
| Age (years)           | Table tennis | 0.66±15.96 | 0.319              |
|                       | Cycling      | 0.78±15.93 |                     |
|                       | Swimming     | 0.67±15.76 |                     |
|                       | Table tennis | 4.73±73.76 |                     |
| Weight (Kg)           | Cycling      | 5.09±71.23 | 0.226              |
|                       | Swimming     | 3.39±73.53 |                     |
|                       | Table tennis | 4.83±178   |                     |
| Height (m)            | Cycling      | 5.15±178   | 0.709              |
|                       | Swimming     | 5.24±179   |                     |
|                       | Table tennis | 1.84±23.39 |                     |
| Body mass index (kg/m²)| Cycling     | 1.54±22.36 | 0.386              |
|                       | Swimming     | 1.46±22.89 |                     |
|                       | Table tennis | 0.80±5.66  |                     |
| Sport history         | Cycling      | 0.71±5.66  | 0.381              |
|                       | Swimming     | 0.68±5.50  |                     |

*Significance level (P≥0.05).

Table 2: The ANOVA analysis of variance test results for between-groups comparison

| Variable    | Sum of squares | df | Mean square | F       | Significance level |
|-------------|----------------|----|-------------|---------|--------------------|
| Tuck jump   | 5.756          | 2  | 2.878       | .845    | .433               |

* Significance level (P≤0.05).

Table 3: The Chi-square test results for TD between-groups comparison

| Value                      | df | Asymptotic Significance level (2-sided) |
|----------------------------|----|----------------------------------------|
| Pearson Chi-Square         | 2  | .240                                   |
| Likelihood Ratio           | 2  | .235                                   |
| Linear-by-Linear Association | 1  | .401                                   |
| N of Valid Cases           | 90 |                                        |

* Significance level (P≤0.05).

Table 4: The Chi-square test results to count the number and percentage of people with and without TD
| Variable | Groups     | with | Percentage | without | Percentage | Total samples |
|----------|------------|------|------------|----------|------------|---------------|
| TD       | Table tennis | 12   | 40%        | 18       | 60%        | 30            |
|          | Cycling     | 6    | 20%        | 24       | 80%        | 30            |
|          | Swimming    | 9    | 30%        | 21       | 70%        | 30            |
|          | Total       | 27   | 30%        | 63       | 70%        | 90            |

Table 5: The Chi-square test results for ligament dominance between-groups comparison

| Value          | df | Asymptotic Significance level (2-sided) |
|----------------|----|----------------------------------------|
| Pearson Chi-Square | 1.886 | .390                                    |
| Likelihood Ratio   | 1.840 | .398                                    |
| Linear-by-Linear Association | 1.721 | .190                                    |
| N of Valid Cases   | 90  |                                         |

* Significance level (P≤0.05).

Table 6: The Chi-square test results to count the number and percentage of people with and without ligament dominance

| Variable            | Groups     | with | Percentage | without | Percentage | Total samples |
|---------------------|------------|------|------------|----------|------------|---------------|
| Ligament dominance  | Table tennis | 8    | 26.66%     | 22       | 73.33%     | 30            |
|                     | Cycling   | 5    | 16.66%     | 25       | 83.33%     | 30            |
|                     | Swimming | 4    | 13.33%     | 26       | 86.66%     | 30            |
|                     | Total     | 17   | 18.88%     | 73       | 81.11%     | 90            |

Table 7: The Chi-square test results for quadriceps dominance between-groups comparison

| Value          | df | Asymptotic Significance level (2-sided) |
|----------------|----|----------------------------------------|
| Pearson Chi-Square | 8.353 | .015                                    |
| Likelihood Ratio   | 8.549 | .014                                    |
| Linear-by-Linear Association | 1.702 | .192                                    |
| N of Valid Cases   | 90  |                                         |

* Significance level (P≤0.05).

Table 8: The Chi-square test results to count the number and percentage of people with and without quadriceps dominance

| Variable            | Groups     | with | Percentage | without | Percentage | Total samples |
|---------------------|------------|------|------------|----------|------------|---------------|
| Quadriceps dominance | Table tennis | 12   | 40%        | 18       | 60%        | 30            |
|                     | Cycling   | 18   | 60%        | 12       | 40%        | 30            |
|                     | Swimming | 7    | 23.33%     | 23       | 76.66%     | 30            |
|                     | Total     | 27   | 30%        | 63       | 70%        | 90            |

Table 9: The Chi-square test results for leg dominance between-groups comparison

| Value          | df | Asymptotic Significance level (2-sided) |
|----------------|----|----------------------------------------|
| Pearson Chi-Square | 2.169 | .338                                    |
| Likelihood Ratio   | 2.171 | .338                                    |
| Linear-by-Linear Association | 2.068 | .150                                    |
| N of Valid Cases   | 90  |                                         |

* Significance level (P≤0.05).
Table 10: The Chi-square test results to count the number and percentage of people with and without leg dominance

| Variable      | Groups      | with | Percentage | without | Percentage | Total samples |
|---------------|-------------|------|------------|---------|------------|---------------|
| Leg dominance | Table tennis| 4    | 13.33%     | 26      | 86.66%     | 30            |
|               | Cycling     | 2    | 6.66%      | 28      | 93.33%     | 30            |
|               | Swimming    | 1    | 3.33%      | 29      | 96.66%     | 30            |
|               | Total       | 7    | 7.77%      | 83      | 92.22%     | 90            |

**Discussions**

The study aimed to study the prevalence of neuromuscular dysfunctions especially TD among the athletic population of rocket, team, and water sports. The results of the present study showed that there is no significant difference between the scores of the tuck jump test and TD among elite athletes in three different sports. It seems that due to the significant differences in the nature, movement pattern, and sport technique and the limitation in the statistical sample among three sports, it is likely that with the presence of professional and high-level athletes, because of the more dominant movement patterns, there will be a significant difference among them.

Although there was no significant difference in this study, by analyzing and comparing the results of tests in three different sports, we found that among 90 athletes in table tennis, cycling, and swimming, 30 athletes from each sport in total, 27 subjects (30%) had TD and 63 subjects (70%) did not have TD. The number of people with TD was 12 (40%) in table tennis, 6 (20%) in cycling, and 9 (30%) in swimming (breaststroke and butterfly stroke swimmers), respectively. Also, the number of people without TD was 18 (60%) in table tennis, 24 (80%) in cycling, and 21 (70%) in swimming, respectively. This means that the most and the least people with TD were table tennis and cycling, respectively.

The present study shows that TD exists in every sport and can also increase the risk of future ACL injury for athletes. Injury prevention training programs are constantly being standardizing. Identifying and modifying injury risk factor is another goal of sport and health professionals (14). The neuromuscular control dysfunctions as one of the risk factors for injury are screened and assessed by tuck jump. It also allows a coach or a trainer to assess the risks of athlete injury without the use of expensive equipment (15). The results of the present study are consistent with the statements of previous researches that have highlighted the importance of the body core stability in various sports activities, examples of which are given in all three sports. According to research, in general, injuries in athletes occur in long-term training (16). In all sports, there are risk factors for injury. Previous studies have shown that the rate of lower extremity injury was higher than the upper extremity, which is between 39–59% of the total injuries presented (lower extremity, upper extremity, and trunk injuries) (17).

Table tennis is a sport characterized by small balls, high speed, a strong rotation, and many variations (18). The trunk plays an important role in the kinetic chain of table tennis techniques, which is part of the generator and transmitter of force. The table tennis service involves a variety of muscles and describes the specific musculoskeletal demands and needs of the trunk as very important. The repetitive and unilateral nature of table tennis movements, which in most situations involves service and continuous
forehand, leads to adaptations and musculoskeletal imbalances in the body which can lead to an injury. According to the studies, the researchers also stated that there is a high percentage of pelvic (core) injuries (5.76%) due to the characteristics of sudden blocking movements in the game of table tennis. Strains and sprains are the most common types of injury in most sports, and also, the research shows that even due to the excessive hyperextension of the knee while the footwork of table tennis players (which is the most important element in table tennis) in short steps compared to long steps, the risk of an ACL injury may increase (17). However, probably due to the unilateral nature of table tennis and its effect on one side of the body muscles, and due to the core stability muscles, one-way muscle strengthening, neuromuscular and musculoskeletal balance, this field generally has the highest number of people with TD (40%).

Core stability is also the basis for power generation when cycling (20). Repetitive movements in cycling and sustained or long-term postures of the pelvis and legs require efficient movement patterns to prevent stress and increased pressure exerted on the musculoskeletal structures of the lower extremity (20). Aside from the role of the trunk and arm muscles when cycling, the upper body may be involved in stabilizing the body, especially when cycling on uneven surfaces such as paving or off-road roads (21). Sustained and repetitive postures or prolonged lumbar flexion are also associated with low back pain. Altered kinematics of the spine, or patterns of core stability muscle activation, appear to be associated with repetitive nature and prolonged activity, leading to an excessive back injury (20). Cyclists often suffer from trunk pain, which is often due to lumbar spine hyperflexion, which potentially puts increasing pressure on the intervertebral discs during excessive forward flexion (22). Therefore, upper body mobility and stability of cycling is also an important factor in preventing injury, because the common injuries of overuse occur in the neck and back regions in long-distance cycling (23). However, it is probably due to the bilateral activity of the hip joints during pedaling and creation of continuous flexion movement of the thigh and its effect on both skeletal muscles (psoas muscles), and its strengthening and constant oscillation in the trunk to both left and right to the same extent and strengthening the stabilizing muscles, especially the core stability muscles and the trunk isometrically, this field generally had the lowest number of people with TD (20%).

The power of core stability muscle groups (abdominal, back, and thigh muscles) is essential to maintain proper posture, balance, and alignment in the aquatic environment (24). If these elements become weak and disturbed, the resistance forces increase and lead to inefficient movements and deterioration of the technique in swimming. Increasing the strength of a swimmer's core stability improves his ability to maintain efficient technique throughout the competition (24). Strength, endurance, coordination, and extensive studies of core stability can be considered as key factors in the development of swimmers' motor skills (24). Lacking central stability or having a core deficit or TD can also be a risk factor for shoulder dysfunction in sports (especially in overhead movements such as swimming) (25). Also, swimmers with core stability weakness or TD tend to oscillate and sway their body instead of maintaining their posture, which leads to more wave tensions, which in turn prevents the swimmer from efficient propulsion (26). Musculoskeletal injuries in the swimmer population are usually due to cumulative and recurrent trauma. Careful monitoring of the volume, intensity, and duration of training by
coaches and trainers can help reduce overuse injuries and identify high-risk swimmers (4). Core stability's stamina and endurance are also essential components of any injury prevention program. Strengthening the core stability muscles should be emphasized in all exercise programs (4). The purpose is to increase the development of pelvic control by preventing anterior pelvic tilt and lumbar lordosis and reducing stress and strain on facet joints, especially in breaststroke and butterfly stroke swimmers (4). However, probably due to the activity of the trunk to control trunk movements and water resistance and its effect on trunk stabilizing muscles and neuromuscular adaptation, this sport has fewer people with TD than table tennis but has more people with TD than cycling (30%).

Although there was no significant difference in this study the value of research was not reduced. According to the present study, valuable information such as the percentage of people with and without TD in various sports, especially table tennis, cycling, and swimming (breaststroke and butterfly stroke swimmers), which have different movement patterns, was found to help future researchers who intend to have research in this field, and the basis for future research, especially to provide core stability exercise protocols.

Finally, it is worth mentioning that this research has been registered and approved by code: IR.GUMS.REC.1398.463 in the research ethics committee of Medical Science of University of Guilan, and also this article is extracted from the master thesis of sports injuries and corrective exercise of the corresponding author at the University of Guilan.

**Conclusions**

According to the outcomes of the present study, it can be concluded that by causing a TD (core stability dysfunction), in addition to a negative impact on the muscles of the core stability, it can also lead to TD and subsequently lead to an ACL injury. Thus, corrective exercises specialists (CES), conditioning coaches and allied health professionals could potentially assess identify and evaluate the athletes by functional tests like the tuck jump test to open the door, screen and then minimize the injuries of the athletes of the future.

**Abbreviations**

TD: Trunk Dysfunction

ACL: Anterior Cruciate Ligament

ANOVA: Analysis of Variance

SPSS: Statistical Package for Social Sciences

**Declarations**
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Availability of data and materials

The data set generated during the current study obtained from athletes was analyzed by SPSS software and can be provided to the esteemed journal upon request.

Ethics approval and consent to participate

This research has been approved by the Research Ethics Committee of Guilan University of Medical Sciences. During the study, all participants signed consent forms to participate in the study. All forms, if requested, can be provided to the respected journal.

Competing interests

Ali Parvaneh Sarand, Hasan Daneshmandi and Ali Asghar Norasteh declare that they have no competing interests.

Consent for publication

The manuscript contains the data of each person, the consents have been taken from all the participants, and if requested, a sample form can be provided to you.

Authors’ contribution

APS was responsible for collecting information, analyzing findings, and organizing the writing of the article, and was instrumental in writing the manuscript. HD and AAN (Supervisors of the first author) were in charge of supervising and supervising the entire implementation process of the project from the beginning to the end of this article. All authors read and approved the final version.

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Figures

Figure 1
Tuck jump test analysis in Kenova software from the sagittal and the frontal planes.