Contents lists available at Islamic World Science Citation Center (ISC)

International Journal of Motor Control and Learning (IJMCL)

Journal Home page: http://www.ijmcl .com

Investigating the Effect of Simultaneous Dual Task Execution on the Balance Position of People with Forward Head Posture

Ali Feiz Khademi [a], Hooman Minoonejad [b, *], Mahdieh Akochakian [c], Yousef Moghadas Tabrizi [d]

[a] PhD student, Department of Pathology and Corrective Movements, Kish International University, Kish, Iran. Email: alifeizkhademi@ut.ac.ir
[b] Associate Professor, Department of Sports injury and biomechanics, Faculty of Sport Sciences and health, university of Tehran, Tehran, Iran. Email: H.minoonejad@ut.ac.ir
[c] Assistant Professor, Department of Physical Education and Sport Sciences, Kish International University, Kish, Iran. Email: makoochakian@ut.ac.ir
[d] Assistant Professor, Department of Sports injury and biomechanics, Faculty of Sport Sciences and health, university of Tehran, Tehran, Iran. Email: moghadas@ut.ac.ir

ARTICLE INFO

Article history:

Received: 2023/04/17

Accepted: 2023/08/12

Available online: 2023/08/14

Keywords:

Balance,

Dual task,

Forward head

Posture

ABSTRACT

Background: The present study has been conducted with the aim of the effect of the simultaneous implementation of the dual task on the dynamic balance of people with forward head posture.
Methods: In this quasi-experimental study, 40 male students with forward head posture and 40 normal male students were purposefully selected to participate in the present study. After familiarizing the participants with the test implementation conditions (dynamic balance with cognitive task and dynamic balance without cognitive task), each of the tests was performed three times, and between each performance, the subject rested for 30 seconds. **Results**: The results shown that there is significant difference between the dynamic balance of the participants with forward head posture position and normal participants, and the participants with forward head posture statistically have weaker dynamic balance ($P<0.05$). Also, the implementation of the dual task has a significant effect on the balance of both groups of participants with forward head and normal posture and statistically weakens the dynamic balance of participants with forward head posture and normal participants ($P<0.05$).
Conclusion: In general, the results of the research made it clear that the posture of the forward head posture will cause the loss and decrease of the stability of the person's posture. Also, in both groups of people with forward head and normal posture, performing a dual task leads to the weakening of postural stability.

1. Introduction

In today's world, mechanization of lifestyle, high use of computers and technological tools, especially among young people, has caused wrong postural habits, especially in the head and neck area, which is one of the most common disorders of the cervical spine is the protrusion of the head (Nemmers, Miller, & Hartman, 2009). Forward head posture (FHP) in a person causes the extension of the atlanto-occipital joint and the upper cervical spine and also increases the flexion of the lower cervical and upper thoracic vertebrae (Nemmers et al., 2009).

Since the abnormality of the FHP is accompanied by structural changes in the cervical spine and head, it also affects the sense of the position of the neck muscles (Shaghayegh-Fard, Ahmadi, Maroufi, & Sarrafzadeh, 2015). Proprioception is an important part of the sensory-body system, which is responsible for providing afferent information to the central nervous system and thereby provides control of the muscle system function by the nervous system. Also, the information obtained from proprioception, together with the information received from the vestibular and visual systems, is necessary for a person's awareness of the position of the head on the trunk and in space. Proprioception collects information from the structures around the neck, including muscles, joints and skin (Palmgren, Lindeberg, Nath, & Heikkilä, 2009). In general, FHP causes abnormal contractions and muscle imbalance in the neck area, dysfunction in the neuromuscular system, changes in the sensitivity of muscle spindles, followed by proprioceptive defects, changes in the function of mechanoreceptors, and as a result, disturbances in coordination and (Gade & Wilson, 2007; M.-Y. Lee, Lee, & Yong, 2014) balance becomes.

We should not forget that postural stability depends on the reaction and complex relationships between proprioception and vision, sensory and vestibular systems, in order to coordinate movements in response to various requests and challenges (Tsay,

Corresponding author: Hooman Minoonejad, Associate Professor, Department of Sports injury and biomechanics, Faculty of Sport Sciences and health, university of Tehran, Tehran, Iran. E-mail address: H.minoonejad@ut.ac.ir

International Journal of Motor Control and Learning 2023; 5 (3) 43-47

Allen, Leung, & Proske, 2012). The presence of defects in any of the mentioned systems can cause weakness in stability and improper postural orientation, which is sometimes the reason for dizziness in people. Due to the importance of proprioception for performing coordinated and intersegmental corrective movements, its receptors in the neck region are important inputs. so that they have reflexive, central and unitary connections with vestibular systems, vision and sensory-motor control. Sensory-motor control system based on received and input information from vision, vestibular, proprioceptive systems and especially the presence of integrated neural network in the central nervous system, provides suitable movement output for head control, eye movement and postural stability (Fortier & Basset, 2012). It seems that the continuation of neck posture disorder reduces the validity of vision to control posture and has a negative effect on balance. Damage or dysfunction of the proprioceptive receptors in the neck area can be the reason for this sensorimotor disorder (Williams, Tarmizi, & Treleaven, 2017). Since FHP causes muscle imbalance, continuous and irregular contraction of the suboccipital, neck and shoulder muscles and can disrupt the proprioceptive information received from the neck muscles as a sensory pathological model. cause dysfunction in posture control.

Postural stability is the overall output of motor control and body coordination steps to maintain stability during static and dynamic activities, which has a direct relationship with proprioceptive afferents and complex sensory-motor activities (Ghai, Driller, & Ghai, 2017). The information related to the effect of FHP on the degree of postural stability in static and dynamic states is different. Abbasi et al. (2020) showed that there is a significant difference in the stability of postural dynamics between the two groups of forward head position and the normal group in both open and closed eyes. While they did not report a significant difference for static postural stability (Abbasi, Alizadeh, Rajabi, & Mohammadi, 2020). On the other hand, the research findings of Lee et al. (2016) show that FHP has a greater effect on static balance control than dynamic balance control (J.-H. Lee, 2016) Also, Ahmadi poor et al. (2020) showed that people with FHP have severe dynamic postural stability dysfunction (Ahmadipoor, Khademi-Kalantari, Rezasoltani, Naimi, & Akbarzadeh-Baghban, 2022). In addition, the findings of Raikar et al. (2018) also indicate the effect of FHP on the static and dynamic balance of people (Raykar, Tajne, & Palekar, 2018). On the other hand, the researchers admit that different measurement tools related to the balance and the type of job of the subjects can be one of the most important factors in creating inconsistencies in the study results. According to the mentioned materials and the need to further investigate the issue in different societies and with different jobs, according to the research team, it is necessary to conduct a study to investigate the dynamic balance in students with forward head position while performing dual tasks.

From the results of the research, it is found that reducing the amount of attention in conscious control for postural control increases the probability of disorder in coordination and stability (Toner & Moran, 2014). It can be said that several studies have investigated the relationship between dual tasks and the dependence of the amount of attention (Schaefer, Jagenow, Verrel, & Lindenberger, 2015; Toner & Moran, 2014). Dual task performance is the ability to coordinate performance in two performance activities that take place simultaneously. According to the theories of conscious processing, the change of attention may cause the automatic functions of the motor system, which can ultimately be beneficial for improving the functional performance of the individual (Boes et al., 2012). However, as the task becomes more complex, cognitive processing increases and then leads to cognitive-motor interference (Lanzarin et al., 2015). Finally, this increase in central interference will affect both cognitive and motor functions. According to these theories, it may also affect the function of the neural pathway that is the interface between cognitive and motor functions. Also, when a continuous input is directed as a dual task with a main task, it may affect the performance of cognitive tasks or the main task (Lanzarin et al., 2015).

Since people suffering from FHP suffer from disorders of neck position sense, proprioceptive sense and postural control, in this study, we intended to investigate the relationship between students' dynamic balance and cognitive resources when performing dual and mental tasks.

2. Materials and Methods

2.1. Participants

The current research method is semi-experimental based on the application of an intervention variable (cognitive task). The statistical population of the research consisted of male students with FHP of University of Tehran. According to the entry and exit criteria and in a targeted manner, 40 students who had a more severe FHP were considered as having FHP and 40 of those with the lowest FHP were selected as normal people for comparison (Table 1). The selection of this number of samples was adapted by calculating the power (G * Power version 3.1.9.2) using alpha of 5%, beta of 80% and Di Cohen's effect size of 0.6.

Inclusion criteria include male gender with an age range of 19 to 28 years, a score of less than 3 on the visual pain scale (VAS) in the neck area, having a craniovertebral angle greater than 55 degrees for normal people and less than 45 degrees for people with FHP. R includes: inability to fully perform tasks, observing pathological symptoms History of fractures and dislocations, surgery and traumatic injuries in the neck area, disorders in the vestibular system, neurological diseases, history of acute head injuries and movement imbalance, headache and dizziness, migraine.

According to the principle of information preservation and confidentiality, all the steps, as well as possible benefits and risks arising from the research, were explained and clarified to the people before signing the informed consent forms to participate in the study, and they were able to participate in each step of the study. They should cancel the research they wanted.

2.2. Procedures

To measure balance in this study, we used the dynamic balance test of Y. The research results show that this test has excellent intra-test reliability of 0.88 to 0.99(Greenberg et al., 2019). To perform the Y test, first the person with the superior leg was placed on the fixed platform located in the center of the machine. Then the subject tried to move the indicators of all three directions, anterior, posterior-internal and posterior-external, with his other foot to the farthest possible place. The final grade of the subject was calculated based on the relevant formula (Greenberg et al., 2019).

Also, the research of Taheri et al. (2019) was used to perform the dual task in Males ahead, which was the simultaneous execution of mathematical calculations while performing the balance test. The test method was such that as soon as the subject performed the balance test, after saying a number by the examiner, the subject started counting down by subtracting three units, and at the same time the person's voice was recorded, and then the number of responses and the relative error of the person was counted (Taheri, Khademi-Kalantari, Davoudi, & Akbarzadeh Baghban, 2019).

2.3. Data analysis

Descriptive statistics methods were used to calculate the central indices, dispersion and draw graphs related to data analysis. Also, in

International Journal of Motor Control and Learning 2023; 5 (3) 43-47

order to check the normality of the data, the Shapiro Wilk test was used and to check the equality of variance of the study variables, the Levine test was used. In addition, two-way analysis of variance (group (FHP and normal) x dual task (with and without cognitive task)) was used. Data analysis was done using SPSS version 24 and default alpha at a significance level of 0.05.

3. Results

The demographic characteristics of the studied samples are presented in **Table 1**. The results of the Shapiro-Wilk test for the variables of dynamic balance and brain waves in all groups and conditions are higher than 0.05. As a result, the data distribution is normal. In order to analysis the effect of dual task performance on the dynamic balance of people with and without FHP, each direction of dynamic balance was analyzed separately.

Table 1.
The mean and standard deviation related to the age, height and weight of the subjects (Mean ± standard deviation)

Group	n	Age (yrs)	Length (cm)	Weight (Kg)
FHP	40	23.19 ± 2.49	178.74 ± 3.29	78 ± 3.49
control (normal)	40	24.76 ± 2.39	178.56 ± 2.28	77 ± 3.24

Table 2.
The results related to the two-way analysis of variance test for the implementation of dynamic balance in the anterior direction

Test Direction	Effect	Total excuses	Df	mean square	F	Sig	Eta squared
Anterior	Dual task	1554/72	1	1554/72	39/87	0/001	0/220
	group	735/42	1	735/42	38/17	0/001	0/119
	Dual task × group	0/008	1	0/008	0/002	0/998	0/002
Posterior internal	Dual task	1191/31	1	1191/31	48/36	0/001	0/201
	group	1036/73	1	1036/73	42/15	0/001	0/184
	Dual task × group	0/25	1	0/28	0/009	0/941	0/001
Posterior external	Dual task	1922/42	1	1922/42	52/17	0/001	0/287
	group	1654/88	1	1654/88	44/49	0/001	0/241
	Dual task × group	21/77	1	22/93	0/584	0/456	0/005

According to **Table 2**, the main effect of the conditions and the main effect of the group is significant in all directions of the test ($P \leq 0.05$). However, the interactive effect is not significant in any direction ($P \geq 0.05$). Based on the results the subjects had weaker dynamic balance skills in all three directions of the balance test in the dual task conditions compared to the subjects in the basic task conditions ($P \leq 0.05$). Also, the participants of the FHP group showed weaker dynamic balance skills in all three directions, anterior, posterior-internal, and posterior-external, compared to the participants of the normal group ($P \leq 0.05$).

4. Discussion and conclusion

The aim of the present research was to investigate the effect of performing dual tasks on the control of dynamic balance of subjects with FHP. From the findings of the research, we concluded that there is a significant difference between the dynamic balance of subjects with FHP and subjects without defects, and FHP subjects statistically have weaker dynamic balance.

Accordingly, Ahmadi poor et al. (2020) showed that a severe disorder in dynamic postural stability occurs in people with forward head position (Ahmadipoor et al., 2022). Also, Abbasi et al. (2020) concluded that FHP can be one of the factors causing disturbances in dynamic postural stability (Abbasi et al., 2020). In addition, Raikar et al. (2018) showed that FHP has an effect on reducing static and dynamic balance (Raykar et al., 2018).

On the other hand, Abbasi et al (2020) showed that the FHP does not have a significant effect on the static balance of students (Abbasi et al., 2020). It seems that since static testing on the Biodex balance meter platform is not that challenging, it may not be able to provide any difference in performance and that the sample size is small.

People with FHP change the position of their joints and muscles compared to the original position, and it is unlikely that correct information is sent to the central nervous system (CNS) in this regard (Ha & Sung, 2020). It seems that the position of the cervical vertebrae and the agonist and antagonist muscles have changed with the intensification of the neck arch and joint and muscle receptors are not able to transmit correct information (M.-Y. Lee et al., 2014). With deviations and deformities of the spine, the muscles on one side become tight and the other side becomes weak. Based on this, it leads to lack of coordination between these muscles and muscle imbalance. The neck region also significantly affects posture control and maintaining stability against gravity (Swait, Rushton, Miall, & Newell, 2007). Also, the neck region has a specialized proprioceptive system, which means they are probably related to the visual and vestibular systems due to the abundance of muscle spindles and mechanical receptors in this area. Proprioception also affects visual neck reflexes and tonic neck reflexes, that is, they are vital in regulating head, eye and body posture stability (Swait et al., 2007). During continuous movements of the neck, visual, vestibular, and depth senses are altered based on the continuous alternation of muscle length, visual field, and multilevel interaction of the vertebrae. On the other hand, forward head position is associated with pain, fatigue, joint erosion, spasm, muscle tension, muscle imbalance and decreased proprioceptiveness (Koseki, Kakizaki, Hayashi, Nishida, & Itoh, 2019). All these cases can be among the possible factors for the occurrence of postural stability disorders in FHP people.

International Journal of Motor Control and Learning 2023; 5 (3) 43-47

Other results of the present study showed that the implementation of dual tasks (equilibrium-cognitive) had a significant effect on the dynamic balance of the participants with FHP and normal participants and statistically weakened the dynamic balance in the participants with FHP. FHP and the participants were normal.

However, consistent with the present study, Bayon et al. (2021) showed that performing cognitive tasks that require attention causes disturbances in the postural control of patients with cervical dystonia (Baione et al., 2021). In addition, Crisafoli et al. (2021) showed that performing a dual task worsens walking performance in cervical dystonia patients (Crisafulli et al., 2021). Some theories have been presented to explain the problems in performing dual tasks. The most common of them are capacity sharing, bottleneck and mutual dialogue (Pashler, 1994).

According to the theory of capacity sharing, which is the most accepted theory, doing two tasks at the same time reduces the performance capacity of each task due to the capacity sharing for the tasks. In the bottleneck (task-switching) model, parallel processing may be impossible for some mental operations. Some operations may simply require a single mechanism to be dedicated to them for a period of time. When two tasks require the mechanism simultaneously, a bottleneck occurs and one or both tasks are delayed or otherwise disrupted (Pashler, 1994).

Talley et al. (2008) suggested that differential activation of the cerebral cortex in higher neural centers can influence task prioritization, further enhancing conscious attention while performing cognitive or motor tasks (Talelli, Ewas, Waddingham, Rothwell, & Ward, 2008). Therefore, it can be said that attention is an important variable to maintain postural stability in dual task conditions in individuals with FHP and a sufficient attention function is needed to establish postural control and balance in such patients under dual task conditions. During the assessment of dual tasks, the two tasks that are performed simultaneously in a dual task pattern can be two cognitive, motor, or motor and cognitive tasks (Saxena, Cinar, Majnemer, & Gagnon, 2017). Impaired performance of dual tasks, i.e. reduction in performance of one or both tasks, can be due to age or conditions related to people's illness (Bekkers et al., 2018). Hence, individuals with FHP may experience reduced functional capacity when performing two activities that require simultaneous attention, such as subtracting three units of numbers from each other and maintaining postural stability, resulting in impaired dual-task performance (Krampe, Schaefer, Lindenberger, & Baltes, 2011). They may have a tendency to prioritize the performance of a motor task, which is postural stability, in the presence of a cognitive or other challenging motor task (Doumas, Rapp, & Krampe, 2009).

In this research, we tried to gain a better understanding of the relationship between the neural activity related to the musculoskeletal system and the performance of dual tasks in normal and postural impaired individuals. But this study is limited to a specific test measurement device and protocol. Therefore, the use of apparatus or laboratory tests of balance or another form of dual-task implementation may provide similar or completely different findings. This study was only conducted on male students aged 19-28, and therefore the generalization of the results of this study to other factors such as gender, age, occupation may be dependent, so that the level of activity and balance may be relatively lower or higher. They give, it will be a difficult task. Also, this study only used the cognitive task to create a dual task, it is possible that the motor dual task has different results compared to the current results. Therefore, it is suggested that in future research, in addition to using more reliable laboratory tools (force plate, Biodex balance meter, posteurography), a dual task with a movement nature should be applied, and the postural stability and brain activity of people with an FHP and normal posture should be measured. to be It will also be interesting to examine the variables of gender and athletes in different sports. Finally, we came to the conclusion that FHP reduces and creates weakness in postural stability, and on the other hand, the implementation of dual tasks in both control and experimental groups causes people to decrease postural stability.

Authors' contributions

Conception and design of the study: A.F.Kh, H.M, M. A, Y. M.T; Data collection: A.F.Kh; Data analysis and/or interpretation: A.F.Kh, H.M, M. A, Y. M.T; Drafting of manuscript and/or critical revision: A.F.Kh; Approval of final version of manuscript: A.F.Kh, H.M, M. A, Y. M.T.

Conflicts of interest

The authors declare no conflict of interest.

Funding

This research received no external funding.

Acknowledgment

There is a place for the professors, personnel and students of the University of Tehran, who helped us in the study.

References

Abbasi, H., Alizadeh, M. H., Rajabi, R., & Mohammadi, F. (2020). Comparison of static and dynamic postural stability between individuals with and without forward head posture. Physical Treatments-Specific Physical Therapy Journal, 10(3), 127-134. https://doi.org/10.32598/ptj.10.3.364.3

Ahmadipoor, A., Khademi-Kalantari, K., Rezasoltani, A., Naimi, S.-S., & Akbarzadeh-Baghban, A. (2022). Effect of Forward Head Posture on Dynamic Balance Based on the Biodex Balance System. *Journal of Biomedical Physics & Engineering*, *12(5)*, *543*. https://doi.org/10.31661/jbpe.v0i0.1912-1036

Baione, V., Ferrazzano, G., Celletti, C., De Rosa, M., Belvisi, D., Fabbrini, G., . . . Conte, A. (2021). Attention-demanding cognitive tasks worsen postural control in patients with cervical dystonia: a case-control study. *Frontiers in Neurology*, *12*, *666438*. https://doi.org/10.3389/fneur.2021.666438 PMid:33889130 PMCid: PMC8056005

Bekkers, E. M., Dockx, K., Devan, S., Van Rossom, S., Verschueren, S. M., Bloem, B. R., & Nieuwboer, A. (2018). The impact of dual-tasking on postural stability in people with Parkinson's disease with and without freezing of gait. *Neurorehabilitation and neural repair*, *32(2)*, *166-174*. https://doi.org/10.1177/1545968318761121 PMid:29554851

Boes, M. K., Sosnoff, J. J., Socie, M. J., Sandroff, B. M., Pula, J. H., & Motl, R. W. (2012). Postural control in multiple sclerosis: effects of disability status and dual task. *Journal of the neurological sciences*, *315(1-2)*, *44-48*. https://doi.org/10.1016/j.jns.2011.12.006 PMid:22236888

Crisafulli, O., Trompetto, C., Puce, L., Marinelli, L., Costi, S., Abbruzzese, G., . . . Pelosin, E. (2021). Dual task gait deteriorates gait performance in cervical dystonia patients: a

International Journal of Motor Control and Learning 2023; 5 (3) 43-47

pilot study. *Journal of Neural Transmission, 128, 1677-1685.* https://doi.org/10.1007/s00702-021-02393-1
PMid:34324056 PMCid:PMC8536592

Doumas, M., Rapp, M. A., & Krampe, R. T. (2009). Working memory and postural control: adult age differences in potential for improvement, task priority, and dual tasking. *Journals of Gerontology: Series B, 64(2), 193-201.* https://doi.org/10.1093/geronb/gbp009
PMid:19255088 PMCid: PMC2655174

Fortier, S., & Basset, F. A. (2012). The effects of exercise on limb proprioceptive signals. *Journal of Electromyography and Kinesiology, 22(6), 795-802.* https://doi.org/10.1016/j.jelekin.2012.04.001
PMid:22579804

Gade, V. K., & Wilson, S. E. (2007). Position sense in the lumbar spine with torso flexion and loading. *Journal of applied biomechanics, 23(2), 93-102.* https://doi.org/10.1123/jab.23.2.93
PMid:17603129

Ghai, S., Driller, M., & Ghai, I. (2017). Effects of joint stabilizers on proprioception and stability: A systematic review and meta-analysis. *Physical Therapy in Sport, 25, 65-75.* https://doi.org/10.1016/j.ptsp.2016.05.006
PMid:28262354

Greenberg, E. T., Barle, M., Glassman, E., Jacob, L., Jaafar, H., Johnson, A., . . . Jung, M.-K. (2019). Reliability and stability of the Y Balance Test in healthy early adolescent female athletes. *Orthopaedic Journal of Sports Medicine, 7(3_suppl).* https://doi.org/10.1177/2325967119S00051
PMCid:PMC6446341

Ha, S.-Y., & Sung, Y.-H. (2020). A temporary forward head posture decreases function of cervical proprioception. *Journal of exercise rehabilitation, 16(2), 168.* https://doi.org/10.12965/jer.2040106.053
PMid:32509702 PMCid:PMC7248444

Koseki, T., Kakizaki, F., Hayashi, S., Nishida, N., & Itoh, M. (2019). Effect of forward head posture on thoracic shape and respiratory function. *Journal of physical therapy science, 31(1), 63-68.* https://doi.org/10.1589/jpts.31.63
PMid:30774207 PMCid: PMC6348172

Krampe, R. T., Schaefer, S., Lindenberger, U., & Baltes, P. B. (2011). Lifespan changes in multi-tasking: concurrent walking and memory search in children, young, and older adults. *Gait & posture, 33(3), 401-405.* https://doi.org/10.1016/j.gaitpost.2010.12.012
PMid:21251833

Lanzarin, M., Parizzoto, P., Libardoni, T. d. C., Sinhorim, L., Tavares, G. M. S., & Santos, G. M. (2015). The influence of dual-tasking on postural control in young adults. *Fisioterapia e Pesquisa, 22, 61-68.*

Lee, J.-H. (2016). Effects of forward head posture on static and dynamic balance control. *Journal of physical therapy science, 28(1), 274-277.* https://doi.org/10.1589/jpts.28.274
PMid:26957773 PMCid:PMC4756019

Lee, M.-Y., Lee, H.-Y., & Yong, M.-S. (2014). Characteristics of cervical position sense in subjects with forward head posture. *Journal of physical therapy science, 26(11), 1741-1743.* https://doi.org/10.1589/jpts.26.1741
PMid:25435690 PMCid: PMC4242945

Nemmers, T. M., Miller, J. W., & Hartman, M. D. (2009). Variability of the forward head posture in healthy community-dwelling older women. *Journal of geriatric physical therapy, 32(1), 10-14.* https://doi.org/10.1519/00139143-200932010-00003
PMid:19856630

Palmgren, P. J., Lindeberg, A., Nath, S., & Heikkilä, H. (2009). Head repositioning accuracy and posturography related to cervical facet nerve blockade and spinal manipulative therapy in healthy volunteers: a time series study. *Journal of Manipulative and Physiological Therapeutics, 32(3), 193-202.* https://doi.org/10.1016/j.jmpt.2009.02.003
PMid:19362229

Pashler, H. (1994). Dual-task interference in simple tasks: data and theory. *Psychological bulletin, 116(2), 220.* https://doi.org/10.1037/0033-2909.116.2.220
PMid:7972591

Raykar, R., Tajne, K., & Palekar, T. (2018). Effect of forward head posture on static and dynamic balance. *World Journal of Pharmaceutical Research, 7(9), 797-808.*

Saxena, S., Cinar, E., Majnemer, A., & Gagnon, I. (2017). Does dual tasking ability change with age across childhood and adolescence? A systematic scoping review. *International journal of developmental neuroscience, 58, 35-49.* https://doi.org/10.1016/j.ijdevneu.2017.01.012
PMid:28167051

Schaefer, S., Jagenow, D., Verrel, J., & Lindenberger, U. (2015). The influence of cognitive load and walking speed on gait regularity in children and young adults. *Gait & posture, 41(1), 258-262.* https://doi.org/10.1016/j.gaitpost.2014.10.013
PMid:25455434

Shaghayegh-Fard, B., Ahmadi, A., Maroufi, N., & Sarrafzadeh, J. (2015). The evaluation of cervical position sense in forward head posture subjects and its comparison with normal subjects. *Rehabilitation, 16(1).*

Swait, G., Rushton, A. B., Miall, R. C., & Newell, D. (2007). Evaluation of cervical proprioceptive function: optimizing protocols and comparison between tests in normal subjects. *Spine, 32(24), E692-E701.* https://doi.org/10.1097/BRS.0b013e31815a5a1b
PMid:18007229

Taheri, S. H., Khademi-Kalantari, K., Davoudi, M., & Akbarzadeh Baghban, A. (2019). Attention and Visual Demands of Postural Control in Patients with Forward Head Posture. *The Scientific Journal of Rehabilitation Medicine, 8(4), 247-256.*

Talelli, P., Ewas, A., Waddingham, W., Rothwell, J. C., & Ward, N. S. (2008). Neural correlates of age-related changes in cortical neurophysiology. *Neuroimage, 40(4), 1772-1781.* https://doi.org/10.1016/j.neuroimage.2008.01.039
PMid:18329904 PMCid: PMC3715371

Toner, J., & Moran, A. (2014). In praise of conscious awareness: A new framework for the investigation of "continuous improvement" in expert athletes. *Frontiers in psychology, 5, 769.* https://doi.org/10.3389/fpsyg.2014.00769
PMid:25076931 PMCid:PMC4100439

Tsay, A., Allen, T. J., Leung, M., & Proske, U. (2012). The fall in force after exercise disturbs position sense at the human forearm. *Experimental brain research, 222, 415-425.* https://doi.org/10.1007/s00221-012-3228-z
PMid:22941313

Williams, K., Tarmizi, A., & Treleaven, J. (2017). Use of neck torsion as a specific test of neck related postural instability. *Musculoskeletal Science and Practice, 29, 115-119.* https://doi.org/10.1016/j.msksp.2017.03.012
PMid:28371703