ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.5336/healthsci.2024-105306

Comparison of Sensory Processing and Kinesiophobia in Older Adults with and without Type 2 Diabetes Mellitus and Examination of the Relationship Between These Parameters: A Case-Control and Correlation Study

Tip 2 Diabetes Mellituslu Olan ve Olmayan Yaşlı Erişkinlerde Duyusal İşleme ile Kinezyofobinin Karşılaştırılması ve Bu Parametreler Arasındaki İlişkinin İncelenmesi: Vaka Kontrol ve Korelasyon Çalışması

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ABSTRACT Objective: To examine the relationship between sensory processing and kinesiophobia in older adults with Type 2 diabetes mellitus (DM). **Material and Methods:** A total of 120 older adults aged 65-75, 60 with Type 2 DM and 60 without Type 2 DM, participated in the study. The older adults in both groups were evaluated with the Adolescent/Adult Sensory Profile (AASP) and Tampa Kinesiophobia Scale (TKS) and the results were compared. Additionally, the relationship between AASP and TKS was examined in older adults with Type 2 DM. **Results:** It was found that older adults with Type 2 DM had worse kinesiophobia and AASP subparameters vestibular, visual, tactile processing and activity level ($p<0.05$). No difference was found between the groups in taste/smell and auditory processing areas ($p>0.05$). In older adults with Type 2 DM, a moderate statistically significant relationship was found between vestibular processing ($p=0.000$, $r=0.459$) and activity level ($p=0.000$, $r=0.519$) with kinesiophobia. A weak statistically significant relationship was found between visual ($p=0.032$, $r=0.277$) and tactile processing ($p=0.043$, $r=0.267$) with kinesiophobia. No statistically significant relationship was found between taste/smell ($p=0.213$, $r=0.163$) and auditory ($p=0.397$, $r=0.111$) with kinesiophobia. **Conclusion:** It was observed that Type 2 DM causes deficiencies in vestibular, visual, tactile processing and activity levels in older adults and that these areas increase the level of kinesiophobia. Occupational therapists and other health professionals should evaluate all sensory areas for older adults with Type 2 DM and plan interventions by considering the relationship of these areas with physical and psychological parameters, especially kinesiophobia.

Keywords: Type 2 diabetes mellitus; older adult; sensory processing; kinesiophobia; occupational therapy

ÖZET Amaç: Tip 2 diabetes mellitusu (DM) olan yaşlı erişkinlerde duyusal işlemleme ile kinezyofobi arasındaki ilişkinin incelenmesidir. **Gereç ve Yöntemler:** Çalışmaya 65-75 yaş arası Tip 2 DM'li 60 ve Tip 2 DM olmayan 60 toplamda 120 yaşlı erişkin katıldı. Her iki gruptaki yaşlı erişkinler Adölesan/Yetişkin Duyu Profili [Adolescent/Adult Sensory Profile (AASP)] ve Tampa Kinezyofobi Ölçeği [Tampa Kinesiophobia Scale (TKS)] ile değerlendirilerek sonuçlar karşılaştırıldı. Ayrıca Tip 2 DM'li yaşlı erişkinlerde AASP ile TKS arasındaki ilişki incelendi. **Bulgular:** Tip 2 DM'li yaşlı erişkinlerin kinezyofobi ve AASP alt parametrelerinden vestibüler, görsel, taktil işlemleme ve aktivite seviyesinin daha kötü olduğu tespit edildi ($p<0,05$). Tat/koku ve işitme işlemleme alanlarında gruplar arasında fark bulunmadı ($p>0,05$). Tip 2 DM'li yaşlı erişkinlerde kinezyofobi ile vestibüler işlemleme ($p=0,000$, $r=0,459$) ve aktivite seviyesi ($p=0,000$, $r=0,519$) arasında istatistiksel olarak orta düzeyde anlamlı ilişki bulundu. Kinezyofobi ile görsel ($p=0,032$, $r=0,277$) ve taktil işlemleme ($p=0,043$, $r=0,267$) arasında ise istatistiksel olarak zayıf anlamlı ilişki bulundu. Tat/koku ($p=0,213$, $r=0,163$) ve işitme işlemleme ($p=0,397$, $r=0,111$) ile kinezyofobi arasında istatistiksel olarak anlamlı ilişki bulunmadı. **Sonuç:** Tip 2 DM'nin yaşlı erişkinlerde vestibüler, görsel, taktil işlemleme ve aktivite seviyesinde yetersizlikler oluşturduğu ve bu alanların kinezyofobi düzeyini artırdığı görüldü. Ergoterapistler ve diğer sağlık profesyonelleri Tip 2 DM'li yaşlı erişkinler için tüm duyu alanlarına ait değerlendirmeleri yapmalı ve bu alanların başta kinezyofobi olmak üzere fiziksel ve ruhsal parametreler ile ilişkisini göz önünde bulundurarak müdahaleler planlamalıdır.

Anahtar Kelimeler: Tip 2 diabetes mellitus; yaşlı erişkin; duyu işlemleme; kinezyofobi; ergoterapi

TO CITE THIS ARTICLE:
Cemali M, Belhan Çelik S. Comparison of sensory processing and kinesiophobia in older adults with and without Type 2 diabetes mellitus and examination of the relationship between these parameters: A case-control and correlation study. Turkiye Klinikleri J Health Sci. 2025;10(1):61-8.

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Peer review under responsibility of Turkiye Klinikleri Journal of Health Sciences.

Received: 29 Aug 2024 ***Received in revised form:*** 21 Oct 2024 ***Accepted:*** 07 Nov 2024 ***Available online:*** 16 Dec 2024

Diabetes mellitus (DM) is a group of metabolic illnesses linked with hyperglycemia that occur as a result of insulin hormone deficiency or any other abnormal insulin release. In Türkiye, the prevalence of DM in individuals over the age of 65 is approximately 25% and in those over the age of 75 it is 37.4%. Type 2 DM, one of the most common chronic diseases in old age, constitutes approximately 90-95% of individuals with DM.[1]

Type 2 DM is a disease with a poor prognosis and causes acute and chronic problems when not controlled, and hyperglycemia causes long-term problems in different organs, including nerve endings, eyes, vessels, heart and kidneys.[2] Long-term uncontrolled glycemia can produce micro and macrovascular alterations that contribute to dysfunction in the sensory and motor systems.[3] Peripheral neuropathy and retinopathy are two typical microvascular problems that contribute to increased posture and balance abnormalities, as well as falls.[4]

The control of balance and posture in the human body is dependent on the proper processing and integration of signals from three systems in the central nervous system: visual, somatosensory, and vestibular. Any one of the three sensory systems may be impacted by Type 2 DM.[3] The most prevalent cause of blindness in individuals with DM is diabetic neuropathy and retinopathy, which are characterized by pain, paresthesia, and sensory loss. The risk of vision loss is 25 times higher in those with diabetes than in those without the disease.[5] A study examined the effect of hypoglycemia on the processing of visual information and found that acute hypoglycemia in particular caused significant deterioration in visual information processing performance and contrast sensitivity. These problems increase the severity of balance problems and the frequency of falls.[6]

Balance issues are more severe in diabetic neuropathy, the most prevalent symptom of Type 2 DM. Somatosensory neuropathy is a condition of the sensory system that affects touch, temperature, pain, bodily movement, and proprioception perception.[7] People with diabetes may have a higher chance of falling and experiencing it again if they have decreased vibration sensitivity, decreased pressure sensitivity, contrast sensitivity, visual acuity, light touch and depth perception.[6] When visual and somatosensory functions are simultaneously impaired, the processing of proprioceptive sensory information for adequate balance control may be reduced. Because of diminished proprioceptive feedback during walking, older adult with Type 2 DM walk slower and with shorter step intervals. These factors increase fear of movement.[8] A study concluded that people with Type 2 DM had higher vestibular dysfunction problems compared to a healthy control group.[9] As a result, it has been stated that as these sensory losses increase in individuals with Type 2 DM, balance and falling problems will increase, which will cause limitations in the individuals' participation in activities.[3]

It is still not fully known how kinesiophobia, the fear of movement, relates to physical function and activity problems associated with advanced aging and chronic disease. The cause of kinesiophobia is usually multifactorial. In addition to the sensory problems caused by DM, the rapid decline in muscle mass and physical function with aging also creates the basis for balance and walking disorders.[10] In summary, deteriorations in the musculoskeletal, somatosensory, visual and vestibular systems that control balance in old age result in balance disorders, caution in movement and kinesiophobia.[11]

Kinesiophobia has a negative impact on walking because it is associated with avoidance of physical activity. Kinesiophobia reduces the activity tolerance of individuals by creating activity limitations as a result of fear of mobility.[12] In a study comparing older adults with Type 2 DM with those who were healthy, it was found that those with Type 2 DM had higher levels of kinesiophobia. The study emphasized that the prevalence of micro and macrovascular complications increased due to the negative effect of kinesiophobia restricting physical movements.[13] In conclusion, there are studies showing a relationship between Type 2 DM and physical activity deficiency, but no study was found examining the relationship between sensory processing and kinesiophobia in individuals with Type 2 DM. Based on this, the aim of the study is to compare sensory processing and kinesiophobia in older adults with and without Type 2 DM and to examine the relationship

between these parameters in older adults with Type 2 DM.

MATERIAL AND METHODS

AIM AND TYPE OF RESEARCH

The aim of this study was to compare sensory processing and kinesiophobia in older adults with and without Type 2 DM and to examine the relationship between these parameters in older adults with Type 2 DM. This study is of the case control and correlation research type. The study agreed with the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement.[14]

RESEARCH POPULATION AND SAMPLE

The universe of the study consists of 120 older adults, 60 with Type 2 DM and 60 without Type 2 DM, between the ages of 65-75. The study was conducted with older adults with and without Type 2 DM who were staying at the "İstanbul Darülaceze Nursing Home" and who agreed to participate in the study by signing the consent form. Information about the individuals was assessed using the sociodemographic information questionnaire, sensory processing were assessed using the Adolescent/Adult Sensory Profile (AASP) and the Tampa Kinesiophobia Scale (TKS) for fear of movement. Sample calculations for two independent group comparison analyses were performed using the G*Power Version 3.1.9.4 package program (Universität Düsseldorf, Germany). Using the AASP as reference, the a priori type, one tail, medium size (effect size; 0.50), 95% confidence interval and 80% power, the minimum sample size was determined as 102 (51 for each group). A total of 128 older adults participated in the study. However, 8 older adults were excluded from the study because the evaluations could not be completed, and the study was completed with 120 older adults (60 older adults in each group).

INCLUSION CRITERIA

The inclusion criteria of the study were being between 65-75 years of age, using oral antidiabetic drugs in the experimental group (not using insulin), getting a score of 24 and above in the Mini Mental State Assessment, knowing how to read and write Turkish, being able to walk independently without the need for an assistive device.[15]

Older adults who had hearing or vision problems that would interfere with the evaluation, who had received chemotherapy, who were in the recovery period of an acute illness, and who had a chronic disease (orthopedic, neurological, psychiatric, cardiac, etc.) that would negatively affect the evaluation were excluded from the study.

DATA COLLECTION METHOD

A simple random sampling method was used to select older adults included in the study. Older adults with and without Type 2 DM in nursing homes were verbally invited to participate in the study, and older adults who accepted the invitation were included in the study. Assessments of older adults were conducted between January and April 2024. Assessments were conducted face-to-face and lasted 35 minutes.

DATA COLLECTION TOOLS

The TKS, the AASP, and the demographic information form were used to gather the research data.

The Demographic Information Form

It consists of the questions that include information about the age, gender and body mass index (BMI).

AASP

A standardized scale with sixty items, the AASP was created using Dunn's Sensory Processing Model. Each question is answered on a 5-point Likert scale that ranges from 1 (almost never) to 5 (almost often). Higher scores on the scale indicate more problems with sensory processing patterns.[16] The test evaluates 6 different sensory processing processes. It includes evaluations related to vestibular processing, visual processing, taste/smell processing, tactile processing, activity level and auditory processing. Aydın carried out the validity and reliability study in Türkiye in 2015. The internal consistency coefficient of the questionnaire was found to be reliable, ranging from 0.66 to 0.70.[17]

TKS

Miller et al. originally developed TKS in 1991, but it was made available. Reprinted by Vlaeyen et al. in

1995 with permission from the authors of the original research.[18] Tunca Yılmaz et al. carried out a validity and reliability assessment of the Turkish version in 2011. The test-retest reliability of the scale is 0.806. The TKS is a 17-item scale meant to assess a person's fear of moving or being wounded again. The scale includes parameters of injury/reinjury and fear avoidance in work-related activities. The scale uses a 4-point Likert scale (1=I strongly disagree, 4=I strongly agree). The overall score ranges from 17 to 68. A high kinesiophobia score on the scale denotes a high level of phobia.[19]

DATA ANALYSES

The data was statistically analyzed using the program IMB SPSS Statistics 29.0.1 (SPSS Inc., Chicago, IL). Descriptive statistics were used for continuous data, mean and standard deviation, and for categorical data, frequency and percentage. Categorical variables comparing the two groups were analyzed using the chi-square test. The Kolmogorov-Smirnov test was used to verify if numerical variables adhered to a normal distribution, and the results showed that they did. The independent samples t-test was performed to compare numerical variables between groups. The relationship between the assessments was investigated using the Pearson correlation test. According to the correlation coefficients, 0.00-0.19 was accepted as no relationship or negligible low relationship, 0.20-0.39 as weak, 0.40-0.69 as moderate relationship, 0.70-0.89 as strong relationship and 0.90-1.0 as very strong relationship.[20] The criterion for statistical significance was determined to be $p<0.05$.

ETHICAL APPROVAL

The study protocol was approved by the University of Health Sciences Hamidiye Non-invasive Investigation Ethics Committee (date: May 18, 2023, no: 23/290). The research was conducted under the guidelines related to the Helsinki Declaration of Human Rights. An informed consent stating the purpose and methods of the study was prepared to notify and inform the participants prior to administering the surveys. The participants were informed that they could resign from the study at any time, and that their information would be kept confidential.

RESULTS

Regarding age (p=0.482) and gender (p=0.854), there was no statistically significant difference between the groups. In the BMI comparison, a statistically significant difference was discovered (p=0.034) (Table 1).

There were statistically significant differences between the groups in terms of TKS (p=0.001), vestibular processing (p=0.018), visual processing (p=0.030), tactile processing (p=0.043) and activity level (p=0.006). There was no statistically significant difference between the groups in terms of taste/smell (p=0.257) and auditory processing (p=0.359). Older adults with Type 2 DM were found to have higher kinesiophobia and lower vestibular, visual, tactile processing and activity level than older adults without Type 2 DM (Table 2).

In older adults with Type 2 DM, a moderate statistically significant relationship was found between vestibular processing (p=0.000, r=0.459) and activ-

TABLE 1: Descriptive characteristics of groups and differences of participants between groups.

	Older adult with Type 2 DM n=60		Older adult without Type 2 DM n=60		
	n	%	n	%	p value
Gender					
Female	26	43.3	27	46.7	0.854[a]
Male	34	56.7	33	53.3	
	$\bar{X}$±SD		$\bar{X}$±SD		
Age (years)	68.36±2.55		68.71±2.87		0.482[b]
BMI (kg/m^2)	27.91±4.71		26.24±3.78		0.034[b]*

[a]The p-value of the chi-square test; [b]The p-value of the independent samples t-test; *p<0.05; DM: Diabetes mellitus; SD: Standard deviation; BMI: Body mass index.

TABLE 2: Comparison of the results of TKS and AASP between the groups.

	Older adult with Type 2 DM n=60 X̄±SD	Older adult without Type 2 DM n=60 X̄±SD	p value
TKS	31.65±8.70	25.78±9.85	0.001*
AASP			
Taste/smell processing	11.13±2.83	10.53±2.94	0.257
Vestibular processing	19.38±4.02	17.73±3.50	0.018*
Visual processing	13.90±3.72	12.63±2.48	0.030*
Tactile processing	18.73±4.21	17.30±3.43	0.043*
Activity level	25.55±4.70	23.15±4.76	0.006*
Auditory processing	13.20±4.79	12.55±2.63	0.359

The p-value of the Mann-Whitney U test, *p<0.05; DM: Diabetes mellitus: SD: Standard deviation; TKS: Tampa Kinesiophobia Scale; AASP: Adolescent/Adult Sensory Profile.

TABLE 3: The correlations between TKS, AASP subheading and pain level in older adult with Type 2 DM.

	Older adult with Type 2 DM n=60 TKS	
	p value	r
Taste/smell processing	0.213	0.163
Vestibular processing	0.000*	0.459
Visual processing	0.032*	0.277
Tactile processing	0.043*	0.262
Activity level	0.000*	0.519
Auditory processing	0.397	0.111

The p-value of the Pearson test; r: Correlation coefficient; *p<0.05; DM: Diabetes mellitus; TKS: Tampa Kinesiophobia Scale; AASP: Adolescent/Adult Sensory Profile.

ity level (p=0.000, r=0.519) with kinesiophobia. A weak statistically significant relationship was found between visual (p=0.032, r=0.277) and tactile processing (p=0.043, r=0.267) with kinesiophobia. No statistically significant relationship was found between taste/smell (p=0.213, r=0.163) and auditory (p=0.397, r=0.111) with kinesiophobia. Kinesiophobia was seen to increase with the decrease in vestibular, visual, tactile processing and activity level in older adults with Type 2 DM (Table 3).

DISCUSSION

According to the results of the study, older adults with Type 2 DM had higher levels of kinesiophobia and lower levels of vestibular, visual and tactile processing and activity compared to older adults without Type 2 DM. No difference was found between the groups in terms of taste/smell and auditory processing. Additionally, a moderate correlation was found between vestibular processing and activity levels with kinesiophobia, and a low correlation was found between visual and tactile processing with kinesiophobia in older adults with Type 2 DM. It was also concluded that kinesiophobia increased with decreased levels of vestibular, visual and tactile processing and activity in older adults with Type 2 DM. No relationship was found between taste/smell and auditory processing with kinesiophobia

Increased insulin resistance due to Type 2 DM negatively affects cardiopulmonary and cardiovascular structure, causing decreases in physical activity capacity.[1] In a study, it was stated that the physical performance and balance of older adults with Type 2 DM were lower than those without Type 2 DM, and this caused the activities of these individuals to be restricted.[21] Another study reported that Type 2 DM increases the number of falls in older adults and that the disease is a factor that inhibits mobility in these individuals.[9] Alpalhão et al. revealed that decreased physical capacity levels in older adults may cause kinesiophobia.[11] In our study, it was determined that older adults with Type 2 DM had higher levels of kinesiophobia than those without Type 2 DM. This is thought to be due to the anxiety that Type 2 DM creates against movement in these individuals due to the negative effects it has on the physical capacity of older adults.

The most important symptoms of Type 2 DM include inadequate nerve conduction due to circulatory problems, and it has been observed that the disrup-

tion of nerve conduction disrupts the sensory-motor connection.[3] One study has shown that Type 2 DM causes balance problems in older adults and this negatively affects physical activity levels.[22] Another study found that Type 2 DM can cause loss of touch sensation and that these losses make individuals vulnerable to injury.[23] Gupta et al. have shown that Type 2 DM can cause damage to the optic nerves, which can lead to irreversible vision loss.[6] In our current study, it was observed that older adults with Type 2 DM had lower vestibular, tactile, visual processing and activity levels than individuals without Type 2 DM. This result is thought to be due to the damage that Type 2 DM has caused in the nervous system. No difference was found between the groups in taste/smell and hearing processing in the study. It can be said that the lack of difference between the groups in these two sensory areas is related to the fact that taste/smell and hearing are not primary symptoms of Type 2 DM and occur in later stages of the disease.[24]

For a good physical activity level and performance in older adults, sensory, perceptual and motor connections must work smoothly.[25] Depending on the symptoms of Type 2 DM, this connection may be disrupted, and this may limit the mobility and activity participation of these individuals.[26] Hewston and Deshpande found in their study that decreased balance and physical capacity in older adults with Type 2 DM may lead to falls.[5] Another study reported that older adults were anxious about moving due to fear of falling and falling, and this caused kinesiophobia.[12] In our study, it was observed that kinesiophobia increased with the decrease in vestibular processing and activity level in older adults with Type 2 DM. It is thought that this situation is due to the fear of mobility that occurs due to the decrease in balance and physical capacity in these individuals due to Type 2 DM. Loss of tactile sensation is seen especially in the lower extremities in older adults with Type 2 DM, and this deficiency can cause injuries and falls.[23] A study conducted with older adults with Type 2 DM found that lower extremity tactile loss decreased mobility and increased fear of falling.[27] Another study found that loss of subplantar tactile sensation in older adults with Type 2 DM negatively impacted walking, causing these individuals to be cautious about movement.[28] In our study, it was concluded that kinesiophobia increased with the decrease in tactile processing. It can be said that this is due to the fear of movement in older adults due to the inadequacy in mobility caused by the loss of tactile sensation due to Type 2 DM symptoms. It has been stated that the sense of vision is an important sense for the depth, speed and reaction of movement.[29] It is known that optic nerve lesion and sensory nerve fiber damage in the macula region of the eye are frequently encountered conditions in Type 2 DM and negatively affect mobility.[30] Kaminsky et al. reported that vision loss due to Type 2 DM in older adults reduces mobility and poses a great risk for independent movement.[31] Roberts-Martínez Aguirre et al. have shown that vision loss due to Type 2 DM can cause problems in environmental orientation in older adults, restrict walking, and cause people to be more cautious about movement.[32] In our study, it was observed that kinesiophobia increased with the decrease in visual processing. It is thought that vision is an important sense for the design of movement and its deficiency significantly restricts movement in older adults and turns into a state of fear. It is known that hearing loss may occur in older adults with Type 2 DM in the advanced stages of the disease.[33] The sense of hearing is an important sense for communicating with the environment and especially for perceiving dangers outdoors.[34] Although there are studies in the literature indicating that hearing loss in older adults indirectly increases the risk of falling and may cause inadequacy in mobility, there is no consensus on this relationship.[35] In our study, no relationship was found between hearing loss and kinesiophobia in older adults with Type 2 DM. It is thought that this result is due to the fact that hearing loss does not have a primary effect on mobility. In order to understand this effect, studies should be planned to evaluate physical parameters and kinesiophobia in older adults with DM with hearing loss. It is known that taste/smell loss occurs especially with the worsening of symptoms of the disease in those with Type 2 DM.[24] According to the results of our study, no relationship was found between smell/taste processing and kinesiophobia. It can be said that the lack of a relationship between taste/smell and kinesiophobia is due to

the fact that kinesiophobia occurs due to physical and psychological reasons.

The study limitations were that these individuals were not classified as having or not having neuropathy and were included in the study without classifying them according to the level of Type 2 DM. Future studies should plan studies in different age groups according to the symptoms and severity of the effects of Type 2 DM. In addition, occupational therapists should make evaluations and interventions in cooperation with physicians according to their areas of expertise for each sensory area. In addition to sensory processing evaluations, occupational therapists should perform more comprehensive balance, functional vision, tactile and activity analysis evaluations in the clinic for older adults with Type 2 DM. Audiologists should be collaborated for hearing evaluation. In addition to all these, the relationship between these sensory areas and activity participation should be examined.

CONCLUSION

It has been observed that kinesiophobia may occur in older adults with Type 2 DM depending on the symptoms of the disease, and that vestibular, visual and tactile processing and activity levels may be negatively affected. It has also been understood that negative effects on these 4 sensory areas increase the level of kinesiophobia. Occupational therapists should evaluate the sensory processing of older adults with Type 2 DM and apply intervention approaches to problematic areas. Older adults with Type 2 DM should undergo routine sensory processing assessment screenings.

Acknowledgements

We would like to thank all older adults and nursing home management who participated in the study.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Mustafa Cemali;* ***Design:*** *Mustafa Cemali, Sümeyye Belhan Çelik;* ***Control/Supervision:*** *Mustafa Cemali, Sümeyye Belhan Çelik;* ***Data Collection and/or Processing:*** *Mustafa Cemali, Sümeyye Belhan Çelik;* ***Analysis and/or Interpretation:*** *Mustafa Cemali;* ***Literature Review:*** *Mustafa Cemali, Sümeyye Belhan Çelik;* ***Writing the Article:*** *Mustafa Cemali, Sümeyye Belhan Çelik;* ***Critical Review:*** *Mustafa Cemali, Sümeyye Belhan Çelik;* ***References and Fundings:*** *Mustafa Cemali, Sümeyye Belhan Çelik;* ***Materials:*** *Mustafa Cemali, Sümeyye Belhan Çelik.*

REFERENCES

1. Cemali M. Tip 2 diabetes mellitusu bulunan geriatrik bireylerin fiziksel fonksiyon, yaşam kalitesi, günlük yaşam aktivitelerinin değerlendirilmesi ve beslenme ile ilişkilendirilmesi [Yüksek lisans tezi]. Ankara: Hacettepe Üniversitesi; 2017. [Erişim tarihi: 20 Haziran 2024]. Erişim linki: [Link]
2. Altunok H, Atalay BI, Önsüz MF, Işıklı B. Yaşlılık döneminde önerilen tarama testleri [Recommended screening tests in old age]. TAF Preventive Medicine Bulletin. 2016;15(6):588-95. [Crossref]
3. El Bakkali S, Taeymans J, Senior COS, Dirinck E, Vereeck L, Vissers D. Does diabetes mellitus type 2 affect vestibular function? A systematic review and meta-analysis. Diabetes Epidemiology and Management. 2021;4:100035. [Crossref]
4. Schwartz AV, Vittinghoff E, Sellmeyer DE, Feingold KR, de Rekeneire N, Strotmeyer ES, et al; Health, Aging, and Body Composition Study. Diabetes-related complications, glycemic control, and falls in older adults. Diabetes Care. 2008;31(3):391-6. Erratum in: Diabetes Care. 2008;31(5):1089. [Crossref] [PubMed] [PMC]
5. Hewston P, Deshpande N. Falls and balance impairments in older adults with type 2 diabetes: Thinking Beyond Diabetic Peripheral Neuropathy. Can J Diabetes. 2016;40(1):6-9. [Crossref] [PubMed]
6. Gupta P, Aravindhan A, Gand ATL, Man REK, Fenwick EK, Mitchell P, et al. association between the severity of diabetic retinopathy and falls in an asian population with diabetes: the singapore epidemiology of eye diseases study. JAMA Ophthalmol. 2017;135(12):1410-6. [Crossref] [PubMed] [PMC]
7. Jacobs KM. Somatosensory system. In: Kreutzer JS DeLuca J, Caplan B, eds. Encyclopedia of Clinical Neuropsychology. 1st ed. New York: Springer; 2011. p.2320-4.

8. Roman de Mettelinge T, Cambier D, Calders P, Van Den Noortgate N, Delbaere K. Understanding the relationship between type 2 diabetes mellitus and falls in older adults: a prospective cohort study. PLoS One. 2013;8(6): e67055. [Crossref] [PubMed] [PMC]
9. Vongsirinavarat M, Mathiyakom W, Kraiwong R, Hiengkaew V. Fear of falling, lower extremity strength, and physical and balance performance in older adults with diabetes mellitus. J Diabetes Res. 2020;2020:8573817. [Crossref] [PubMed] [PMC]
10. Şavkın R, Büker N, Bayrak G, Oğuz G, Topsakal S. Effect of walking exercise on blood parameters in patients with type 2 diabetes mellitus. Istanbul Medical Journal. 2021;22(4):313-9. [Crossref]
11. Alpalhão V, Cordeiro N, Pezarat-Correia P. Kinesiophobia and fear avoidance in older adults: a scoping review on the state of research activity. J Aging Phys Act. 2022;30(6):1075-84. [Crossref] [PubMed]
12. Cemali M, Sarı M, Öztürk D, Elmas Ö, Karaduman AA. Examination of the relationship between sensory processing skills, kinesiophobia and fear of falling in older adults with hypertension and normotension. Exp Aging Res. 2024:1-13. [Crossref] [PubMed]
13. Turhan A, Albayrak B, Çarlıoğlu A, Gündüz N, Nazlıgül HTKY, Yalçın K. Evaluation of eating disorders, kinesiophobia and dysfunctional attitudes in patients with type 2 diabetes mellitus. Journal of Clinical Medicine of Kazakhstan. 2022;19(3):28-34. [Crossref]
14. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. Lancet. 2007;370(9596):1453-7. [Crossref] [PubMed]
15. Güngen C, Ertan T, Eker E, Yaşar R, Engin F. Standardize Mini Mental Test'in Türk toplumunda hafif demans tanısında geçerlik ve güvenilirliği [Reliability and Validity of The Standardized Mini Mental State Examination in The Diagnosis of Mild Dementia in Turkish Population]. Türk Psikiyatri Dergisi. 2002;13(4):273-81. [Link]
16. Brown C, Cromwell RL, Filion D, Dunn W, Tollefson N. Sensory processing in schizophrenia: missing and avoiding information. Schizophr Res. 2002;55(1-2):187-95. [Crossref] [PubMed]
17. Aydın MŞ. Adolesan/Yetişkin Duyu Profili Anketi Türkçe uyarlamasının geçerlilik güvenilirlik çalışması [Yüksek lisans tezi]. Ankara: Hacettepe Üniversitesi; 2015. [Erişim tarihi: 20 Haziran 2024]. Erişim linki: [Link]
18. Vlaeyen JWS, Kole-Snijders AMJ, Boeren RGB, van Eek H. Fear of movement/(re)injury in chronic low back pain and its relation to behavioral performance. Pain. 1995;62(3):363-72. [Crossref] [PubMed]
19. Tunca Yılmaz Ö, Yakut Y, Uygur F, Uluğ N. Tampa Kinezyofobi Ölçeği'nin Türkçe versiyonu ve test-tekrar test güvenirliği [Turkish version of the Tampa Scale for Kinesiophobia and its test-retest reliability]. Fizyoterapi Rehabilitasyon. 2011;22(1):44-9. [Link]
20. Alpar R. Uzaklık ve benzerlik ölçüleri. Uygulamalı Çok Değişkenli İstatistiksel Yöntemler. 5. Baskı. Ankara: Detay Yayıncılık; 2017. p.153-73.
21. Lin CC, Ou HY, Hsu HY, Cheng KP, Hsieh TJ, Yeh CH, et al. Beyond Sarcopenia: older adults with type II diabetes mellitus tend to experience an elevated risk of poor dynamic balance-a case-control study. BMC Geriatr. 2022;22(1):138. [Crossref] [PubMed] [PMC]
22. Hewston P, Deshpande N. Fear of falling and balance confidence in older adults with type 2 diabetes mellitus: a scoping review. Can J Diabetes. 2018;42(6):664-70. [Crossref] [PubMed]
23. Rinkel WD, van Nieuwkasteele S, Castro Cabezas M, van Neck JW, Birnie E, Coert JH. Balance, risk of falls, risk factors and fall-related costs in individuals with diabetes. Diabetes Res Clin Pract. 2019;158:107930. [Crossref] [PubMed]
24. Catamo E, Tornese G, Concas MP, Gasparini P, Robino A. Differences in taste and smell perception between type 2 diabetes mellitus patients and healthy controls. Nutr Metab Cardiovasc Dis. 2021;31(1):193-200. [Crossref] [PubMed]
25. Torpil B, Uyanık M, Altuntaş O. Huzurevinde yaşayan geriatrik bireylerde denge ve yürüme fonksiyonları ile depresyon ve fonksiyonel bağımsızlık arasındaki ilişkinin incelenmesi [Investigation of relationships between balance and gait functions with depression and functional independence among geriatrics living in nursing home]. Ergoterapi ve Rehabilitasyon Dergisi. 2016;4(2):73-80. [Link]
26. Deshmukh MP, Hase S, Palekar TJ, Baxi G, Wadhokar OC. Effects of sensory and motor strategies for recovery in patients with type 2 diabetes mellitus: a quasi-experimental study. Journal of Datta Meghe Institute of Medical Sciences University. 2024;19(1):66-70. [Crossref]
27. Seo H, Yoon J, Cho OH. Falls, fear of falling, and related factors in patients with diabetic foot disease. Appl Nurs Res. 2023;73:151715. [Crossref] [PubMed]
28. Kraiwong R, Vongsirinavarat M, Hiengkaew V, von Heideken Wågert P. Effect of sensory impairment on balance performance and lower limb muscle strength in older adults with type 2 diabetes. Ann Rehabil Med. 2019;43(4):497-508. [Crossref] [PubMed] [PMC]
29. Ng KD, Mehdizadeh S, Iaboni A, Mansfield A, Flint A, Taati B. Measuring gait variables using computer vision to assess mobility and fall risk in older adults with dementia. IEEE J Transl Eng Health Med. 2020;8:2100609. [Crossref] [PubMed] [PMC]
30. Fukuda T, Bouchi R, Takeuchi T, Nakano Y, Murakami M, Minami I, et al. Association of diabetic retinopathy with both sarcopenia and muscle quality in patients with type 2 diabetes: a cross-sectional study. BMJ Open Diabetes Res Care. 2017;5(1):e000404. [Crossref] [PubMed] [PMC]
31. Kaminsky TA, Mitchell PH, Thompson EA, Dudgeon BJ, Powell JM. Supports and barriers as experienced by individuals with vision loss from diabetes. Disabil Rehabil. 2014;36(6):487-96. [Crossref] [PubMed]
32. Roberts-Martínez Aguirre I, Rodríguez-Fernández P, González-Santos J, Aguirre-Juaristi N, Alonso-Santander N, Mielgo-Ayuso J, et al. Exploring the quality of life related to health and vision in a group of patients with diabetic retinopathy. Healthcare (Basel). 2022;10(1):142. [Crossref] [PubMed] [PMC]
33. Samocha-Bonet D, Wu B, Ryugo DK. Diabetes mellitus and hearing loss: a review. Ageing Res Rev. 2021;71:101423. [Crossref] [PubMed]
34. Agmon M, Lavie L, Doumas M. the association between hearing loss, postural control, and mobility in older adults: a systematic review. J Am Acad Audiol. 2017;28(6):575-88. [Crossref] [PubMed]
35. Wang J, Liu N, Zhao X. Assessing the relationship between hearing impairment and falls in older adults. Geriatr Nurs. 2022;47:145-50. [Crossref] [PubMed]