Asia-Pacific Chiropractic Journal

Improvements in Timed Up and Go Test, pain, and health-related Quality of Life in three geriatric patients with forward head posture receiving Chiropractic care: A Case Series

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Abstract: The purpose of this study was to describe the improvements in the instrumented timed up and go test, pain, and health-related quality of life in three geriatric patients with forward head posture, receiving chiropractic care.

Three geriatric patients presented to a private chiropractic clinic seeking care on different dates. Patient A had a diagnosis of Parkinson's Disease, Patient B had chronic low back pain and failed back surgery syndrome, and Patient C suffered from neck pain and neurogenic bladder.

The patients were evaluated in the timed up and go test while wearing an inertial measurement unit. Grip strength was also measured. Improvements were noted in pain and grip strength after a program of chiropractic care. Also, multiple improvements were observed in the different variables of the timed up and go test.

The results from this case series reveal that a program of postural-based chiropractic care can improve certain timed up and go parameters, grip strength, pain, and health-related quality of life. More research is necessary to establish a cause-and-effect relationship between chiropractic care and improvements in timed up and go variables, which translates into a reduction in the risk of falling and improved quality of life.

Indexing Terms: Chiropractic; timed-up and go, biomechanics, grip strength, vertebral subluxation, geriatric.

Introduction

Research evidence suggests that approximately 25% of the elderly population experiences at least one fall per year, with this number doubling in those over 70 years of age. (Mak et al, 2020; Sharif et al, 2018) The risk of falling is considered an ongoing public health issue, especially in the elderly, (Park, 2018) and because of this the detection of specific risk factors related to loss of balance and risk of falling must be recognised early so that personalised prevention programs can be developed. (Gschwind et al, 2013)

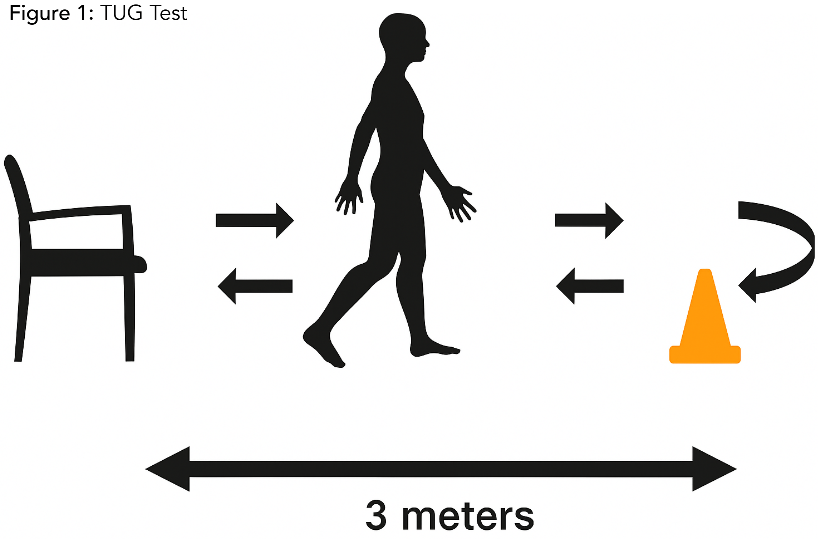
The timed up and go test (TUG) is used to assess balance and to determine the risk of falls in older adults and has recently been shown to be a strong predictor of mortality. (Ascencio et al, 2022) One of the benefits of using the

'… postural-based Chiropractic can improve iTUG parameters & pain in geriatric patients. Grip strength was also improved in all three cases. We recommend The iTUG should be of use in chiropractic clinics …'

TUG is that it is easy to implement in the clinic as long as there is enough space. It was initially developed as a modification to the '*Get up and Go test*' (Mathias et al, 1986) in 1991 by Podsiadlo & Richardson, (1991) and it has shown a high level of test-retest reliability. (Steffen et al, 2002)

The test is performed in a circuit in which the subject stands up from a seated position, walks three meters away from the chair, turns around at a specified point, walks back, and sits on the chair again (Figure 1).

Figure 1: TUG Test



In the past, the only variable of interest for the TUG was the test duration, measured in seconds, and a correlation with the risk of falling was established from this. (Barry et al, 2014) A limitation that has been pointed out by clinicians and researchers alike is that it evaluates balance in a general way; thus it limits the predictive value of the exam. (Barry et al. 2014). Experts have suggested incorporating technology into the TUG to enhance its predictive value. (Vervoort et al, 2016) In recent times, the instrumented version of the TUG (iTUG) has been investigated by many research teams with good results (Caronni et al, 2018; Salarian et al, 2010; Vervoort et al, 2016; van Lummel et al, 2016) The main feature of the iTUG is that it can divide the test into specific sub-phases, potentially yielding a higher sensitivity, thus aiding in the early detection of balance difficulties.

Research has shown that Chiropractic care has a positive effect on balance through improvements in the proprioceptive system (Haavik & Murphy, 2011; Learman et al, 2009; Rogers, 1997), but limited research exists in this subject. (Holt et al, 2012) In older adults, Chiropractic care has been shown to enhance multi-sensory integration and sensorimotor function, which are crucial to maintaining balance. (Holt et al, 2016) In asymptomatic amateur athletes, a program of postural-based Chiropractic care was also shown to improve postural-sway parameters related to sensory-motor improvements. (Osuna & Pérez, 2021) Finally, Chiropractic care can also positively impact balance by improving spinal alignment parameters, which can be assessed through postural and radiographic analysis. (Bae et al, 2020; Haddas et al, 2020) The purpose of this paper is to discuss the positive changes in the iTUG observed in three geriatric patients receiving postural-based chiropractic care.

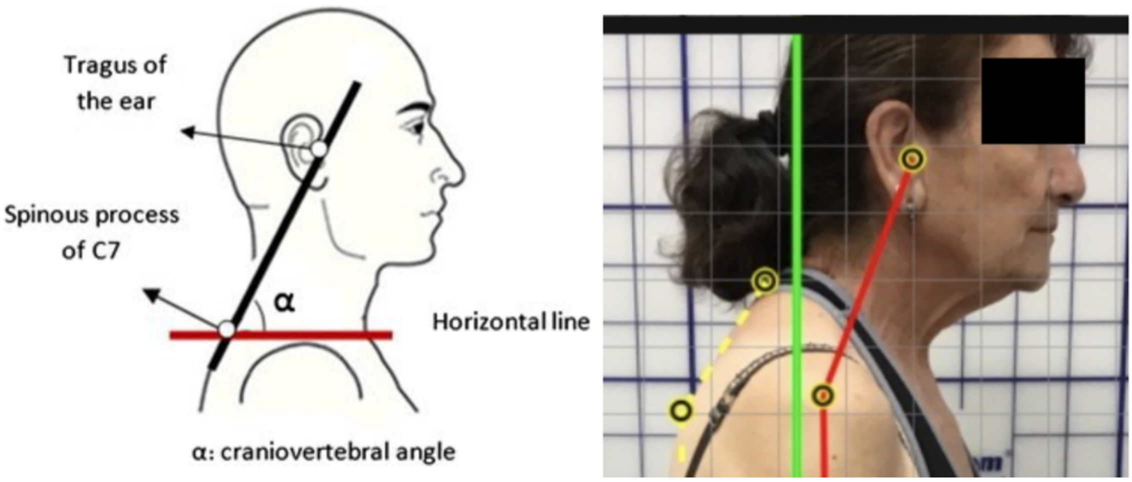
Case reports

Three geriatric patients attended a private Chiropractic clinic seeking care for various conditions. All patients were seen at different time frames and were not related to one another. The patients received a consultation to discuss their conditions and complaints, and they also received a complete Chiropractic evaluation that included 2D postural examination, grip strength, iTUG (with an inertial measurement unit or IMU), and full spine radiographs. Before the submission of this case report, informed consent was obtained from every patient.

The iTUG evaluation was performed by having the subject stand up from a chair, walk three meters away from it, turn around at an orange cone (3-meter mark), walk back, and sit again on the chair. During the evaluation, the subject wore the commercially available IMU G-Sensor- G-Walk® (BTS Bioengineering, Lombardia, Italy) at the L1-L2 spinal level. This sensor comprises a tri-axial accelerometer, a tri-axial gyroscope, and a tri-axial magnetometer, with a maximum sampling frequency of 1000 Hz. (Mangano et al, 2020)

The main variables obtained from the iTUG were total duration (Dur), sit-to-stand duration (SStdDur), stand-to-sit duration (SSitDur), mid-turn duration, end-turn duration, maximum rotational speed during the mid turn, maximum rotational speed during the end turn, average rotational speed during the mid turn, and average rotational speed during the end turn (See tables 2, 3, and 4). Postural analysis was performed using the valid and reliable 2D analysis software, Posture Screen (PostureCo, Inc., Trinity, Florida). (Szucs & Brown, 2018) The cranio-vertebral angle (CVA) was used as a measure of FHP (Figure 2), with less than 50° considered as having the condition. (Kamel et al, 2023)

Figure 2: CVA angle



The handheld digital dynamometer Camry (Zhongshan Camry Electronic Co, Ltd, China) was used for evaluating grip strength (Image 3). This is a low-cost, valid, and reliable handheld dynamometer. (Huang et al, 2022; Panhale & Kothale, 2025.

The radiographic analysis used the methods of biomechanical analysis for spinal subluxation described as the Pettibon method (Jackson et al, 2000) and the Harrison method. (Harrison et al, 2000; Harrison et al, 2002) A summary of the findings concerning all three patients is presented below.

Figure 2: Grip Strength test

Patient A

A 60-year-old Latino female presented to a private chiropractic clinic on 6 June 6th 2021 with the main complaint of left-sided neck pain at a level of 9 out of 10 and radiation to the left hand (See table 1 for body composition). Upon consultation, it was discovered that the patient had a diagnosis of Parkinson's disease (PD) two years before that visit and had noticed a worsening of her posture and increased difficulty walking during this time. The patient stated that the PD diagnosis caused her symptoms of depression.

She had also been diagnosed with hypertension and chronic acid reflux by her primary care provider. She was prescribed Benazepril for the hypertension, Omeprazole for the acid reflux, and Sertraline for the depression. Gabapentin and Baclofen were also prescribed for her neck pain and radiation.

Digital postural evaluation revealed an average cranio-vertebral angle (CVA) of 36.6°, denoting FHP. An average pelvic tilt (PT) of 7.8° was also observed. We chose to focus on sagittal alignment for postural parameters due to the importance of preserving the spine's physiological function in aging populations on this plane. (Wang et al, 2025) Her grip strength was also assessed during that initial visit, with results of 14.8 lbs 6.7kg of pressure on the left hand and 26.4 lbs 12kg on the right hand. As part of the initial evaluation, the Parkinson's Disease Questionnaire (PDQ-39) was also administered. Radiographic findings are observed in Figure 3, and iTUG variables are observed in Table 2. The patient presented no other health concerns.

Table 1: Body composition

	Patient A	Patient B	Patient C
Height (cm):	152	162.5	178
Body Mass (kg):	56.2	79.8	74.8
BMI:	24.3	30.2	23.6

Figure 3: Patient A radiographic findings

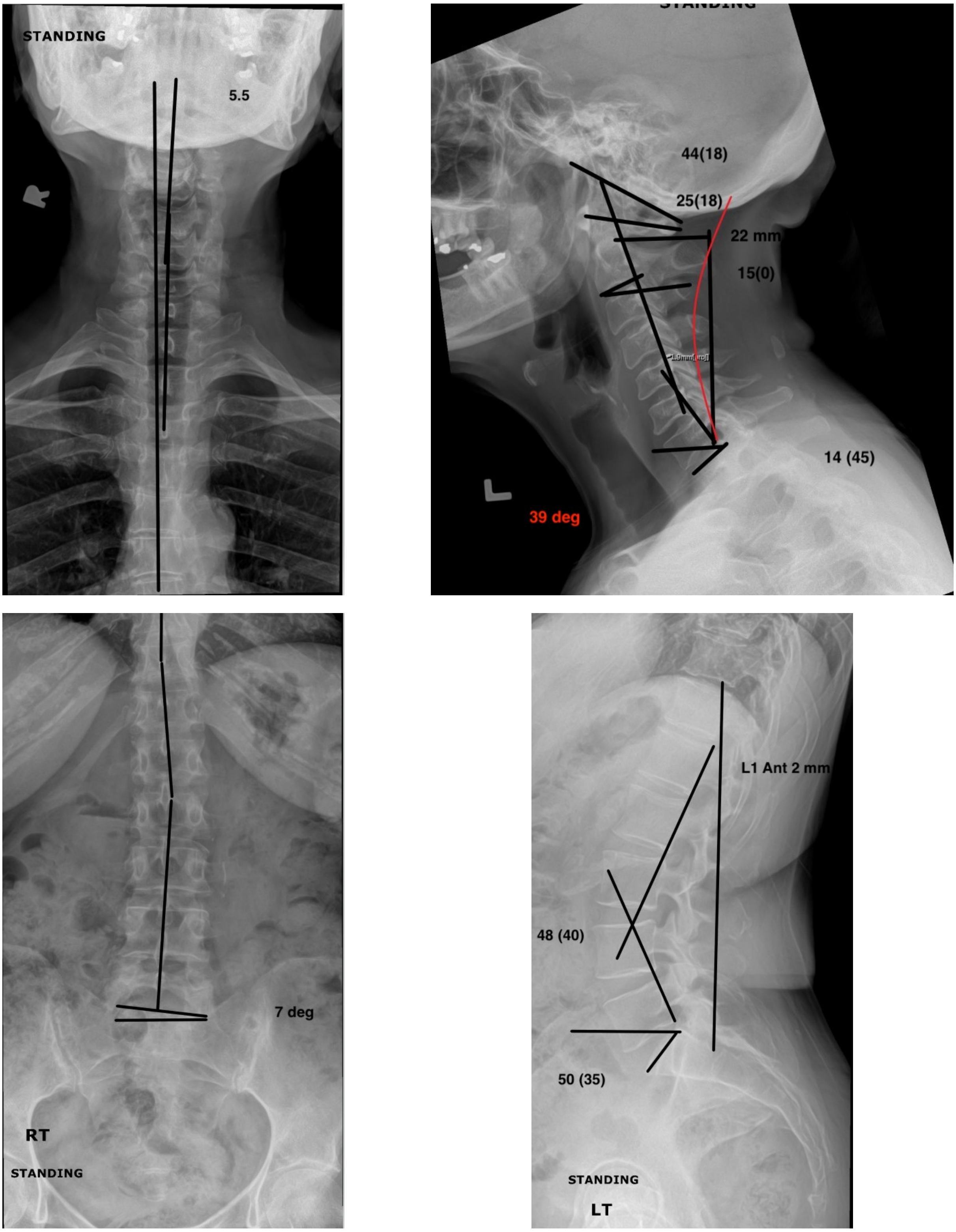


Table 2: iTUG Parameters Patient A

	Dur	SStd Dur	SSit Dur	Mid Turn Dur	End Turn Time	Max Rot Speed Mid	Max Rot Speed End	Avg. Rot Speed Mid	Avg. Rot Speed End
Pre	26.4 S	1.99 S	2.4 S	2.7 S	2.28 S	99.7 deg/S	133 deg/S	54.5 deg/S	71.7 deg/S
Post	22 S	1.9 S	2.0 S	2.7 S	3.36 S	120.4 deg/S	168.8 deg/S	51.9 deg/S	99 deg/S

Patient B

A 73-year-old African American female presented herself to a private chiropractic clinic on 26 October 2021 seeking Chiropractic care. She had a main complaint of low back pain (LBP) and rated it as an 8 out of 10. She also had been diagnosed with Fibromyalgia and osteoarthritis.

The patient had a history of three low back surgeries, the first one in 2003 was a multilevel fusion at L2-3, L3-4, and L4-5. The second surgery was performed in 2006, and according to the patient, it was done to 'create space in the disks'. The final surgery was in 2016 with the goal of implanting a neurostimulator for pain management.

She was prescribed high doses of Tylenol and Lyrica, and during the last two years, she attended a pain clinic monthly to get '*pain injections*' with little help. This case depicts a classic example of Failed Back Surgery Syndrome. (Yeo, 2024)

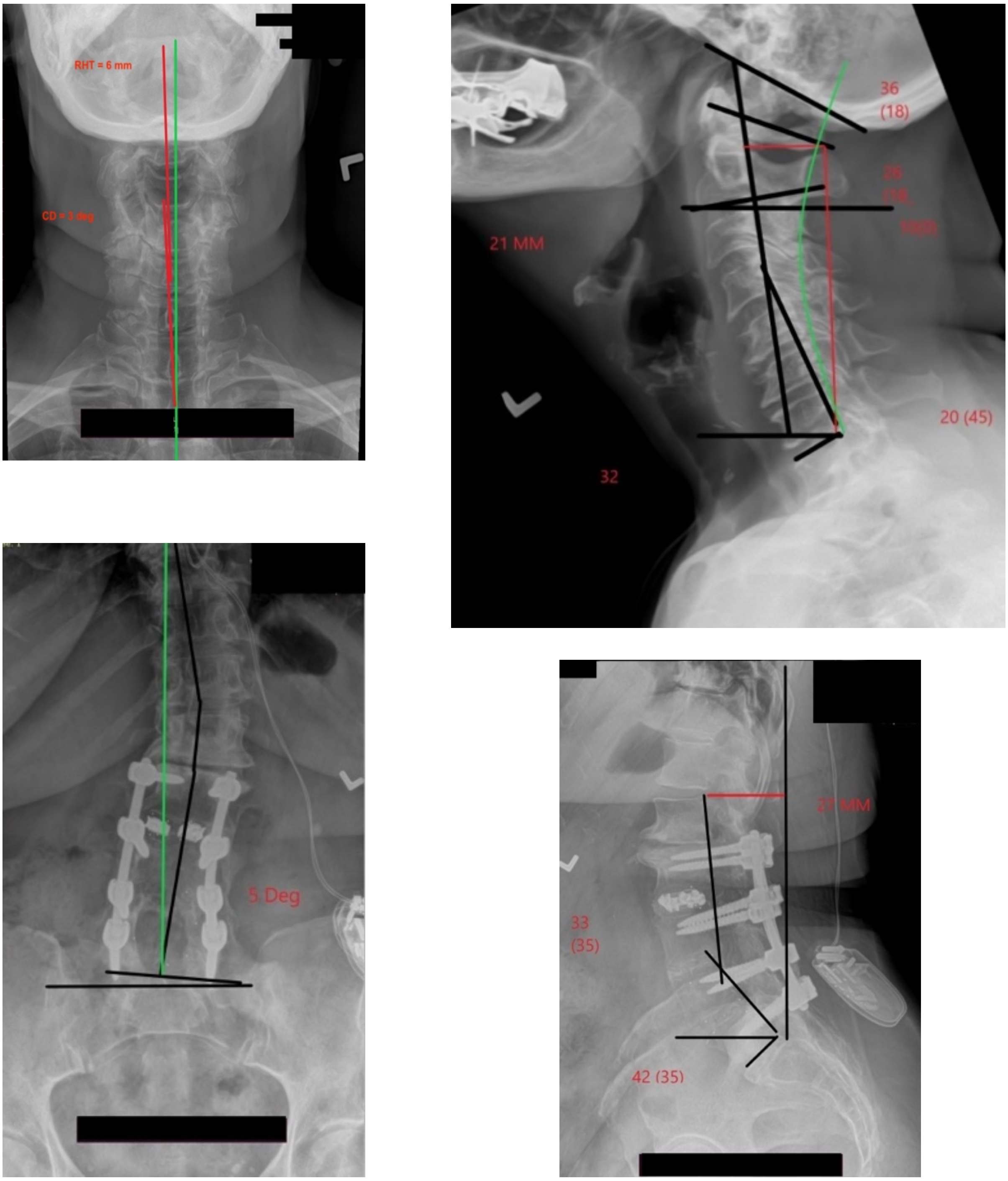
Digital postural evaluation revealed that the patient suffered from FHP with an average CVA of 43.1°. An average PT of 14.4° was also observed. Her grip strength was also assessed in that initial visit, with a result of 18 lbs 8.1kg of pressure on the left hand and 17.5 lbs 8kg on the right hand. As part of her initial examination, the Oswestry Low Back Pain Disability questionnaire (ODI) was also administered.

Radiographic findings are given in Figure 4 and iTUG variables are given in Table 3. There were no other health concerns presented by the patient.

Table 3: iTUG Parameters Patient B

	Dur	SStd Dur	SSit Dur	Mid Turn Dur	End Turn Time	Max Rot Speed Mid	Max Rot Speed End	Avg. Rot Speed Mid	Avg. Rot Speed End
Pre	26.64 S	2.80 S	2.00 S	3.9 S	2.17 S	132.8 deg/S	132.1 deg/S	60.4 deg/S	79.6 deg/S
Post	19.98 S	1.70 S	1.70 S	2.89 S	2.12 S	147.9 deg/S	155.0 deg/S	65.9 deg/S	75.5 deg/S

Figure 4: Patient B radiographic findings



Patient C

An 87-year-old Latino male presented to a chiropractic clinic on 22March 2 2021 seeking chiropractic care. He had a main complaint of neck pain and rated it as a 7 out of 10, which started gradually 3 years ago.

He was also diagnosed with a neurogenic bladder and prostate hyperplasia by his medical doctor and prescribed Tamsulosin. He was also prescribed Valsartan HCTZ, Eliquis, and Amlodipine for hypertension.

Digital postural evaluation revealed that the patient suffered from FHP with an average CVA of 38.2°. An average PT of 4.9° was also observed. His grip strength was also assessed during that initial visit, with results of 34 lbs 15.4kg of pressure on the left hand and 38.8 lbs 17.6kg on the right hand.

As part of his initial examination, the Neck Disability Index (NDI) was also administered. Radiographic findings are given in Figure 5, and iTUG variables are given in Table 4. The patient presented no other health concerns.

Figure 5: Patient C radiographic findings

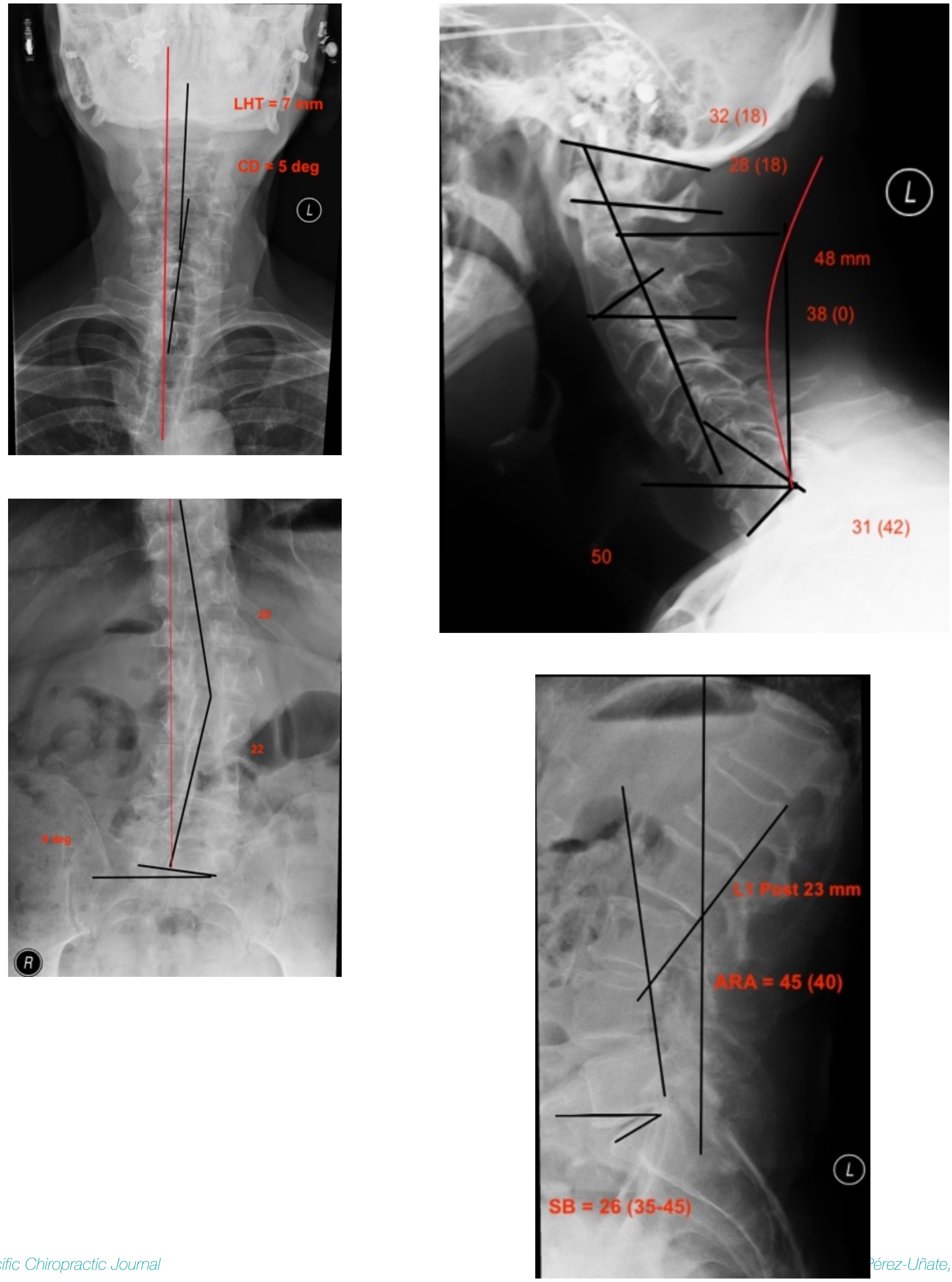


Table 4: iTUG Parameters Patient C

	Dur	SStd Dur	SSit Dur	Mid Turn Dur	End Turn Time	Max Rot Speed Mid	Max Rot Speed End	Avg. Rot Speed Mid	Avg. Rot Speed End
Pre	31.98 S	4.5 S	4.10 S	2.3 S	3.31 S	114.3 deg/S	139.4 deg/S	67.3 deg/S	70.3 deg/S
Post	27.04 S	1.90 S	2.90 S	3.03 S	2.63 S	94.1 deg/S	104.4 deg/S	56.1 deg/S	61.8 deg/S

Intervention and outcomes

All three patients received a postural-based program of Chiropractic care based on each patient's individual examination findings. The program incorporated aspects of the Pettibon system of spinal biomechanics and the Chiropractic Biophysics Technique (CBP®), with the goal of correcting global and regional spinal subluxations (postural) and improving overall sagittal and coronal alignment. (Kent, 1996)

The corrective process included manual and instrument-assisted Chiropractic adjustments based on radiographic analysis, standing repetitive traction, tridimensional wobble seat exercises, and specific use of body weights while standing on a whole-body vibration platform (WBV), to cause muscle-reflex activation and thus achieve improved spinal alignment.

This protocol has been previously described elsewhere. (Morningstar et al, 2004; Morningstar et al, 2005; Morningstar & Jockers, 2009; Osuna & Pérez, 2021; Saunders et al, 2003).

Chiropractic adjustments were performed in an Omni drop table, and the Arthrostim adjusting instrument (IMPAC Inc., Salem, OR, USA) was also used. Patient A was initially seen four times a week, while patients B and C were seen initially three times a week. Standing repetitive traction and wobble seat exercises began with 10 repetitions and increased by 5 repetitions per day until reaching the patient's age in repetitions (ie, a 50-year-old person would do 50 repetitions).

Head and body weighing were performed for 5 to 10 minutes on a WBV platform. Patient A utilised a 10 lb 4.5kg posterior pelvic weight (1st sacral segment), and due to increased rigidity of the neck, no head weight was used. Patient B used a 2 lb 1kg head weight only, and patient C used a 10 lb 4.5kg chest weight (in the front) and a 4 lb 4.5kg head weight. Cervical retraction/extension exercises in a Mirror Image® way were performed by all three patients using the Pro Lordotic band (Circular Traction Supply Inc., Huntington Beach, CA, USA) initially for 10 sets, holding for 5 seconds, and progressing to 10 sets of 10-second holds. A spinal orthotic device (Denneroll™ Pty Ltd, New South Wales, Australia) was used in a progressive manner, starting with 3 minutes and adding 1 minute per day until reaching 20 minutes.

Patient A

Patient A received chiropractic care from 6 June 2021, until 30 June 2021, for a total of twenty-three visits. Because the patient lived in a different state and only came to the clinic for care, a more intensive approach was taken. Postural corrective exercises in the clinic and at home were prescribed to the patient as delineated above.

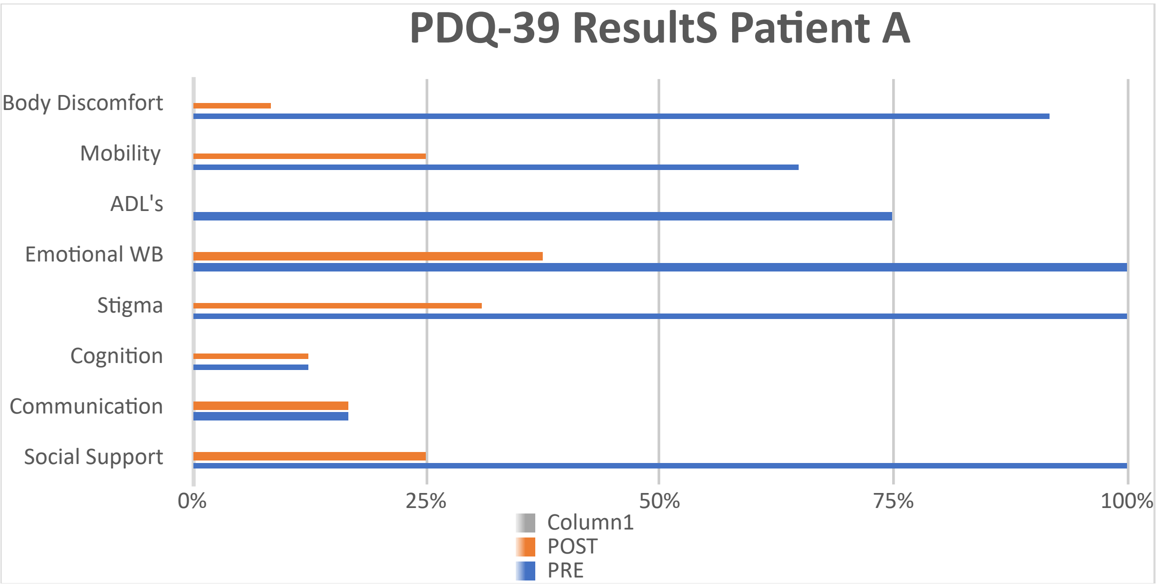
A progress evaluation was performed during the last visit, and all the exams performed during the initial visit were performed again (except x-rays). The level of neck pain improved to a 2 out of 10. The CVA had a significant improvement as it went from 36.6° to 43.1°, and while it did not correct the FHP, it was still significant. PT also improved from an average of 7.8° to 14.9°. Her grip strength also showed significant improvements on both sides, increasing from 14.8 lbs 6.7kg to 39 lbs 17.7kg of pressure on the left hand and from 26.4 lbs 11kg to 53.4 lbs 24.2kg of pressure on the right hand.

The PDQ-39 showed the following significant improvements (lower percentage is better): Mobility from 65% to 25%

- Activities of Daily Living (ADLs) from 75% to 0%
- Emotional Well-Being from 100% to 37.5%
- Stigma from 100% to 31%
- Social Support from 100% to 25%, and
- Body Discomfort from 91.6 % to 8.3%.

The minimal detectable clinical change (MDC) was met for all the positive changes noted above, which means that the improvement was not due to measurement error (Fitzpatrick et al, 2004) (Table 5). Cognition and communication stayed the same before and after care. iTUG results can be observed in Table 2.

Table 5: PDQ-39- Patient A



Patient B

The patient received chiropractic care from 26 October 2021, until 24 March 2022, for a total of thirty-four visits. Postural corrective exercises in the clinic and at home were prescribed to the patient as delineated above.

A progress evaluation was performed during the last visit, and all the exams performed during the initial visit were performed again (except x-rays). The LBP improved to a 2 out of 10, and on some days, it even reached a 0 out of 10. The CVA had a significant improvement as it went from 43.1° to 50.4°, and thus, FHP was corrected. PT also improved from an average of 14.4° to 17.1°. Her grip strength also showed significant improvements on both sides, increasing from 18 lbs 8kg to 26.6 lbs 12kg of pressure on the left hand and from 17.5 lbs 8kg to 32.8 lbs 14.8kg of pressure on the right hand. The ODI denoted a significant improvement, going from 23% initially (moderate disability) to 10% (minimal disability).

Important, the clinical improvement for the ODI in this patient was 13% which is well within the previously published cut-offs for its MDC. (Copay et al, 2008; Johnsen et al, 2013) This means that the improvement was real and not due to measurement error. iTUG results can be observed in Table 3.

Patient C

Patient C received chiropractic care from 22 March 2021, until 23 August 2021, for a total of thirty-three visits. Postural corrective exercises in the clinic and at home were prescribed to the patient as delineated above.

A progress examination was performed during the last visit, and all the exams performed during the initial visit were performed again (except x-rays). The patient noted no change in the neurogenic bladder symptoms and an improvement to 0 out of 10 in the neck pain.

The CVA had a significant improvement as it went from 38.2° to 44.4°, and even when FHP was not corrected, it approximated a healthier alignment. PT also showed a slight improvement from an average of 4.9° to 5.2°. His grip strength also showed significant improvements on both sides, increasing from 34 lbs 14.4kg to 78.2 lbs 35.4kg of pressure on the left hand and from 38.8 lbs 17.6kg to 86.2 lbs 39kh of pressure on the right hand.

`The NDI also showed significant improvement from 28% (mild disability) to 2% (no disability). This change meets the MDC for the NDI in mechanical neck disorders (Cleland et al, 2008). iTUG results can be observed in Table 4.

Discussion

The purpose of this study was to describe the improvements in the instrumented-timed up and go test (iTUG), pain, and health-related quality of life (HRQOL) in three geriatric patients undergoing postural-based Chiropractic care.

The TUG is a simple, practical, and important method for clinicians to assess the risk of falling and overall health in the elderly (Kouda et al, 2025). Importantly, research has found a correlation between TUG times and mortality (Bergland et al, 2017). This strengthens the theory held by many experts, which considers walking gait as '*the sixth vital sign*' based on the speed of walking. (Middleton et al, 2015) The addition of an IMU to the test enables the TUG to be divided into specific sub-phases, which may yield a higher sensitivity, thereby aiding in the detection of the risk of falling (Ortega-Bastidas et al, 2023). This is especially true for the trunk velocity during turning, which is presented in this case series as maximum and average rotational speed at both the mid-turning and end-turning of the iTUG.

Research with stroke patients has found that those with a slower speed of turning (slower trunk velocity when turning) have a higher risk of falling due to poor balance control. (Naito et al, 2025) Furthermore, the risk of falling was elevated by 2.28 times in the same population when the mid-turn interval lasted longer than 3.82 seconds. (Lim et al, 2018)

Balance and risk of falls can be affected by spinal alignment. (Dufvenberg et al, 2018; Godzik et al, 2020). Interestingly, surgical studies have shown that once spinal alignment is improved surgically, balance and gait parameters normalise. (Haddas & Lieberman, 2019; Haddas et al, 2020)

In this study, all three subjects presented with FHP (CVA measurement of less than 50°), and while balance alterations are multifactorial (Wang et al, 2024), it is our belief that FHP was the main factor contributing to the alterations. FHP is considered one of the most common alterations presenting to rehabilitation clinics today (Kendall et al, 2005) and it has been shown to be related to neck pain, altered autonomic function, abnormal sensorimotor control, alterations in postural control, gait abnormalities, alterations in static balance, increased fall risk, alterations in vestibular function, increased cognitive cost during walking, and elevated cortico-muscular coherence in difficult balance tasks. (Abu-Ghosh et al, 2024; Anwar et al, 2025; Heidary et al, 2024; Kamel et al, 2023; Lee, 2016; Lin et al, 2022; Mahmoud et al, 2019; Migliarese & White, 2019; Moustafa et al, 2020).

Somatosensory, visual, and vestibular systems integration is key in the process of balance and prevention of falls. (Alcock, 2018) The vestibular system signals about the position of the head in relation to gravity. The visual system uses visual cues to know where the head is in relation to the environment surrounding the person. The proprioceptive system (part of the somatosensory system) (Delhaye et al, 2018) provides feedback to the position of the head as it relates to the trunk and coordinates both the vestibular and visual systems in the intricate process of postural control. (Peng et al, 2021) Considering this, a probable mechanism in the above-described cases is that of altered cervical proprioception caused by the altered cervical spine alignment (FHP). Interestingly, and strengthening our line of thinking regarding mechanisms of action in these three cases, the improvement (case A and C) and correction (case B) of FHP correlated with the improvements during the iTUG. These findings need to be replicated in larger, more controlled studies in order to establish causation.

Because FHP is considered a vertebral subluxation (VS) in postural-based techniques, (Kent, 1996) Chiropractors must understand its analysis and potential correction since VS has been the focus of Chiropractic practice. (Rosner, 2016) VS can be described as a displacement of the spine either at a regional, global, or intersegmental level affecting the function of the nervous system. Postural techniques in Chiropractic emphasise the global subluxation and require postural and radiographic evaluation for proper analysis. The use of X-rays is considered safe to use as a common tool to evaluate spinal alignment (Oakley et al, 2018; Oakley et al, 2019).

This study is not without limitations. First, there were only three patients, and this does not allow for statistical analysis to be performed. Second, repeat radiographs were not taken to monitor structural changes, due to the clinic not having an X-ray unit in-house. This is considered a limitation because research has suggested that CVA angle measurement is moderately correlated to the C2-C7 Sagittal Vertical Axis (SVA), which is a radiographic measure of FHP (Oakley et al, 2024). Because of this, it cannot be assumed that the improvement in CVA would indicate a correction in the C2-C7 SVA.

The variability of symptoms in the population can also be seen as a limitation for this study. Finally, because many postural correction techniques incorporate multiple aspects of care, we cannot determine which component of the care plan (exercises, adjustments, traction, WBV, etc.) was the biggest contributor to the observed improvement. Pilot studies are on the way to evaluate the above mentioned interventions in the improvement of biomechanical and motor control parameters in various populations.

An important strength of this study is that it was performed in a traditional clinical environment as opposed to a laboratory setting, equal to what any patient seeking Chiropractic care would experience. This improves the ecological validity of the results and can translate into a clearer way into clinical practice.

Conclusion

The results from this case series reveal that postural-based Chiropractic can improve iTUG parameters, pain, and HRQOL in geriatric patients. Furthermore, grip strength was also improved in all three cases.

The iTUG should be of regular use in chiropractic clinics around the world, as it is easy to perform, affordable, and yields a lot of valuable insight regarding the patient's health status. This is especially true in the geriatric population attending our clinics.

This would allow a larger amount of objective data on the benefits that Chiropractic care can confer to the elderly, potentially improving the prevention and early detection of falls. Clearly, more research in controlled environments needs to be performed to establish a cause-and-effect relationship between chiropractic care and improvements in iTUG variables, which can translate into a reduction in the risk of falling.

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Informed consent is held by the author

Cite: Osuna A, Pérez-Uñate A. Improvements in Timed Up and Go Test, pain, and health-related Quality of Life in three geriatric patients with forward head posture receiving Chiropractic care: A Case Series. Asia-Pac Chiropr J. 2025;6.2. www.apcj.net/papers-issue-6-2/#OsunaTUGTest

References

Abu-Ghosh, S., Moustafa, I. M., Ahbouch, A., Oakley, P. A., & Harrison, D. E. (2024). Cognitive load and dual-task performance in individuals with and without Forward Head Posture. Journal of Clinical Medicine, 13(16), 4653. https://doi.org/10.3390/jcm13164653

Anwar, G., Moustafa, I. M., Khowailed, I., Raghunathan, M. R. K., Al Abdi, R., & Harrison, D. E. (2025). Comparison of corticomuscular coherence under different balance paradigms in individuals with and without forward head posture. Scientific Reports, 15(1), 22985. https://doi.org/10.1038/s41598-025-06603-8

Ascencio, E. J., Cieza-Gómez, G. D., Carrillo-Larco, R. M., & Ortiz, P. J. (2022). Timed up and go test predicts mortality in older adults in Peru: A population-based cohort study. BMC Geriatrics, 22(1), 61. https://doi.org/10.1186/s12877-022-02749-6

Bae, Y., & Park, Y. (2020). Head posture and postural balance in community-dwelling older adults who use dentures. Medicina (Kaunas, Lithuania), 56(10), 529. https://doi.org/10.3390/medicina56100529

Barry, E., Galvin, R., Keogh, C., Horgan, F., & Fahey, T. (2014). Is the Timed Up and Go test a useful predictor of risk of falls in community dwelling older adults: A systematic review and meta-analysis. BMC Geriatrics, 14, 14. https://doi.org/10.1186/1471-2318-14-14

Bergland, A., Jørgensen, L., Emaus, N., & Strand, B. H. (2017). Mobility as a predictor of all-cause mortality in older men and women: 11.8 year follow-up in the Tromsø study. BMC Health Services Research, 17(1), 22. https://doi.org/10.1186/s12913-016-1950-0

Caronni, A., Sterpi, I., Antoniotti, P., Aristidou, E., Nicolaci, F., Picardi, M., Pintavalle, G., Redaelli, V., Achille, G., Sciumè, L., & Corbo, M. (2018). Criterion validity of the instrumented Timed Up and Go test: A partial least square regression study. Gait & Posture, 61, 287–293. https://doi.org/10.1016/j.gaitpost.2018.01.015

Cleland, J. A., Childs, J. D., & Whitman, J. M. (2008). Psychometric properties of the Neck Disability Index and Numeric Pain Rating Scale in patients with mechanical neck pain. Archives of Physical Medicine and Rehabilitation, 89(1), 69–74. https://doi.org/10.1016/j.apmr.2007.08.126

Copay, A. G., Glassman, S. D., Subach, B. R., Berven, S., Schuler, T. C., & Carreon, L. Y. (2008). Minimum clinically important difference in lumbar spine surgery patients: a choice of methods using the Oswestry Disability Index, Medical Outcomes Study questionnaire Short Form 36, and pain scales. The Spine Journal: Official Journal of the North American Spine Society, 8(6), 968–974. https://doi.org/10.1016/j.spinee.2007.11.006

Delhaye, B. P., Long, K. H., & Bensmaia, S. J. (2018). Neural basis of touch and proprioception in primate cortex. Comprehensive Physiology, 8(4), 1575–1602. https://doi.org/10.1002/cphy.c170033

Dufvenberg, M., Adeyemi, F., Rajendran, I., Öberg, B., & Abbott, A. (2018). Does postural stability differ between adolescents with idiopathic scoliosis and typically developed? A systematic literature review and meta-analysis. Scoliosis and Spinal Disorders, 13, 19. https://doi.org/10.1186/s13013-018-0163-1

Fitzpatrick, R., Norquist, J. M., & Jenkinson, C. (2004). Distribution-based criteria for change in health-related quality of life in Parkinson's disease. Journal of Clinical Epidemiology, 57(1), 40–44. https://doi.org/10.1016/j.jclinepi.2003.07.003

Godzik, J., Frames, C. W., Smith Hussain, V., Olson, M. C., Kakarla, U. K., Uribe, J. S., Lockhart, T. E., & Turner, J. D. (2020). Postural stability and dynamic balance in adult spinal deformity: Prospective pilot study. World Neurosurgery, 141, e783–e791. https://doi.org/10.1016/j.wneu.2020.06.010

Gschwind, Y. J., Kressig, R. W., Lacroix, A., Muehlbauer, T., Pfenninger, B., & Granacher, U. (2013). A best practice fall prevention exercise program to improve balance, strength / power, and psychosocial health in older adults: Study protocol for a randomized controlled trial. BMC Geriatrics, 13, 105. https://doi.org/10.1186/1471-2318-13-105

Heidary, Z., Pirayeh, N., Mehravar, M., & Shaterzadeh Yazdi, M. J. (2024). Evaluating the stability limits between individuals with mild and moderate-to-severe grades of forward head posture. Middle East Journal of Rehabilitation and Health Studies, 11(4), Article e144970. https://doi.org/10.5812/mejrh-144970

Huang, L., Liu, Y., Lin, T., Hou, L., Song, Q., Ge, N., & Yue, J. (2022). Reliability and validity of two hand dynamometers when used by community-dwelling adults aged over 50 years. BMC Geriatrics, 22(1), 580. https://doi.org/10.1186/s12877-022-03270-6

Johnsen, L. G., Hellum, C., Nygaard, O. P., Storheim, K., Brox, J. I., Rossvoll, I., Leivseth, G., & Grotle, M. (2013). Comparison of the SF6D, the EQ5D, and the Oswestry Disability Index in patients with chronic low back pain and degenerative disc disease. BMC Musculoskeletal Disorders, 14, 148. https://doi.org/10.1186/1471-2474-14-148

Kamel, M., Moustafa, I. M., Kim, M., Oakley, P. A., & Harrison, D. E. (2023). Alterations in cervical nerve root function during different sitting positions in adults with and without Forward Head Posture: A Cross-Sectional Study. Journal of Clinical Medicine, 12(5), 1780. https://doi.org/10.3390/jcm12051780

Kendall, F.P., McCreary, E.K., Provance, P.G., Rodgers, M.M., & Romani, W.A. (2005). Muscles: Testing and Function with Posture and Pain. Fifth Edition. Lippincott Williams & Wilkins

Kent, C. (1996). Models of vertebral subluxation: A review. Journal of Vertebral Subluxation Research, 1(1), 1-7. Retrieved from https://chiro.org/Graphics_Box_LINKS/FULL/Kent_Model_of_Subluxation.pdf

Kouda, K., Banno, M., Konishi, H., Umemoto, Y., Mikami, Y., Tajima, F., & Kubo, A. (2025). The relationship between physical function and quality of life in elderly people requiring long-term care. Progress in Rehabilitation Medicine, 10, 20250005. https://doi.org/10.2490/prm.20250005

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

Lim, S.-y., Lee, B.-j., & Lee, W.-h. (2018). Receiver operating characteristic curve analysis of the timed up and go test as a predictive tool for fall risk in persons with stroke: A retrospective study. Physical Therapy Rehabilitation Science, 7(2), 54-60. https://doi.org/10.14474/ptrs.2018.7.2.54

Lin, G., Zhao, X., Wang, W., & Wilkinson, T. (2022). The relationship between forward head posture, postural control and gait: A systematic review. Gait & Posture, 98, 316–329. https://doi.org/10.1016/j.gaitpost.2022.10.008

Mahmoud, N. F., Hassan, K. A., Abdelmajeed, S. F., Moustafa, I. M., & Silva, A. G. (2019). The relationship between Forward Head Posture and neck pain: a Systematic review and meta-analysis. Current Reviews in Musculoskeletal Medicine, 12(4), 562–577. https://doi.org/10.1007/s12178-019-09594-y

Mak, T. C. T., Wong, T. W. L., & Ng, S. S. M. (2021). Visual-related training to improve balance and walking ability in older adults: A systematic review. Experimental Gerontology, 156, 111612. https://doi.org/10.1016/j.exger.2021.111612

Mangano, G. R. A., Valle, M. S., Casabona, A., Vagnini, A., & Cioni, M. (2020). Age-Related changes in mobility evaluated by the Timed Up and Go Test instrumented through a single sensor. Sensors (Basel, Switzerland), 20(3), 719. https://doi.org/10.3390/s20030719

Mathias, S., Nayak, U. S., & Isaacs, B. (1986). Balance in elderly patients: The "get-up and go" test. Archives of Physical Medicine and Rehabilitation, 67(6), 387–389.

Middleton, A., Fritz, S. L., & Lusardi, M. (2015). Walking speed: The functional vital sign. Journal of Aging and Physical Activity, 23(2), 314–322. https://doi.org/10.1123/japa.2013-0236

Migliarese, S., & White, E. (2019). Review of Forward-Head Posture and vestibular deficits in older adults. Current Geriatrics Reports, 8(4), 194–201. https://doi.org/10.1007/s13670-019-00292-8

Moustafa, I. M., Youssef, A., Ahbouch, A., Tamim, M., & Harrison, D. E. (2020). Is Forward Head Posture relevant to autonomic nervous system function and cervical sensorimotor control? A cross-sectional study. Gait & Posture, 77, 29–35. https://doi.org/10.1016/j.gaitpost.2020.01.004

Oakley, P. A., Cuttler, J. M., & Harrison, D. E. (2018). X-Ray imaging is essential for contemporary chiropractic and manual therapy spinal rehabilitation: Radiography increases benefits and reduces risks. Dose-Response: A Publication of International Hormesis Society, 16(2), 1559325818781437. https://doi.org/10.1177/1559325818781437

Oakley, P. A., Ehsani, N. N., & Harrison, D. E. (2019). Repeat radiography in monitoring structural changes in the treatment of spinal disorders in chiropractic and manual medicine practice: Evidence and safety. Dose-Response :A Publication of International Hormesis Society, 17(4), 1559325819891043. https://doi.org/10.1177/1559325819891043

Oakley, P. A., Moustafa, I. M., Haas, J. W., Betz, J. W., & Harrison, D. E. (2024). Two methods of Forward Head Posture assessment: Radiography vs. posture and their clinical comparison. Journal of Clinical Medicine, 13(7), 2149. https://doi.org/10.3390/jcm13072149

Ortega-Bastidas, P., Gómez, B., Aqueveque, P., Luarte-Martínez, S., & Cano-de-la-Cuerda, R. (2023). Instrumented timed up and go test (iTUG)-more than assessing time to predict falls: A systematic review. Sensors (Basel, Switzerland), 23(7), 3426. https://doi.org/10.3390/s23073426

Panhale, V., Kini, R., & Kothale, S. (2025). Reliability and validity of Camry dynamometer for isometric hand grip strength measurement in healthy Indian adults. Journal of Hand and Microsurgery, 17(4), 100291. https://doi.org/10.1016/j.jham.2025.100291

Park S. H. (2018). Tools for assessing fall risk in the elderly: A systematic review and meta-analysis. Aging Clinical and Experimental Research, 30(1), 1–16. https://doi.org/10.1007/s40520-017-0749-0

Peng, B., Yang, L., Li, Y., Liu, T., & Liu, Y. (2021). Cervical proprioception impairment in neck pain-pathophysiology, clinical evaluation, and management: A narrative review. Pain and Therapy, 10(1), 143–164. https://doi.org/10.1007/s40122-020-00230-z

Podsiadlo, D., & Richardson, S. (1991). The timed "Up & Go": A test of basic functional mobility for frail elderly persons. Journal of the American Geriatrics Society, 39(2), 142–148. https://doi.org/10.1111/j.1532-5415.1991.tb01616.x

Rosner A. L. (2016). Chiropractic identity: A neurological, professional, and political assessment. Journal of Chiropractic Humanities, 23(1), 35–45. https://doi.org/10.1016/j.echu.2016.05.001.

Salarian, A., Horak, F. B., Zampieri, C., Carlson-Kuhta, P., Nutt, J. G., & Aminian, K. (2010). iTUG, a sensitive and reliable measure of mobility. IEEE Transactions on Neural Systems and Rehabilitation Engineering: A Publication of the IEEE Engineering in Medicine and Biology Society, 18(3), 303–310. https://doi.org/10.1109/TNSRE.2010.2047606

Sharif, S. I., Al-Harbi, A. B., Al-Shihabi, A. M., Al-Daour, D. S., & Sharif, R. S. (2018). Falls in the elderly: Assessment of prevalence and risk factors. Pharmacy Practice, 16(3), 1206. https://doi.org/10.18549/PharmPract.2018.03.1206

Steffen, T. M., Hacker, T. A., & Mollinger, L. (2002). Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds. Physical Therapy, 82(2), 128–137. https://doi.org/10.1093/ptj/82.2.128

Szucs, K. A., & Brown, E. V. D. (2018). Rater reliability and construct validity of a mobile application for posture analysis. Journal of Physical Therapy Science, 30(1), 31–36. https://doi.org/10.1589/jpts.30.3

van Lummel, R. C., Walgaard, S., Hobert, M. A., Maetzler, W., van Dieën, J. H., Galindo-Garre, F., & Terwee, C. B. (2016). Intra-rater, inter-rater and test-retest reliability of an instrumented timed up and go (iTUG) test in patients with Parkinson's Disease. PloS One, 11(3), e0151881. https://doi.org/10.1371/journal.pone.0151881

Vervoort, D., Vuillerme, N., Kosse, N., Hortobágyi, T., & Lamoth, C. J. (2016). Multivariate Analyses and Classification of Inertial Sensor Data to Identify Aging Effects on the Timed-Up-and-Go Test. PloS one, 11(6), e0155984. https://doi.org/10.1371/journal.pone.0155984

Wang, J., Li, Y., Yang, G. Y., & Jin, K. (2024). Age-related dysfunction in balance: A comprehensive review of causes, consequences, and interventions. Aging and Disease, 16(2), 714–737. https://doi.org/10.14336/AD.2024.0124-1

Wang, W., Wang, Z., Wang, D., Liu, C., Kong, C., Zhu, W., Pan, F., Li, X., Chen, X., & Lu, S. (2025). Age-related changes and spinal sagittal alignment in asymptomatic community dwelling adults over 50. Spine, 10.1097/BRS.0000000000005248. Advance online publication. https://doi.org/10.1097/BRS.0000000000005248

Yeo J. (2024). Failed back surgery syndrome-terminology, etiology, prevention, evaluation, and management: A narrative review. Journal of Yeungnam Medical Science, 41(3), 166–178. https://doi.org/10.12701/jyms.2024.00339