

Video Article

Substantiating Appropriate Motion Capture Techniques for the Assessment of Nordic Walking Gait and Posture in Older Adults

Christopher M. Dalton¹, Julie Nantel¹

¹School of Human Kinetics, Faculty of Health Sciences, University of Ottawa

Correspondence to: Julie Nantel at jnantel@uottawa.ca

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Abstract

Nordic walking (NW) has become a safe and simple form of exercise in recent years, and in studying this gait pattern, various data collection techniques have been employed, each with positives and negatives. The aim was to determine the effect of NW on older adult gait and posture and to determine optimal use of different data collection systems in both short and long duration analysis. Gait and posture during NW and normal walking were assessed in 17 healthy older adults (age: 69 ± 7.3). Participants performed two trials of 6 Minute Walk Tests (6MWT) (1 with poles (WP) and 1 without poles (NP)) and 6 trials of a 5m walk (3 WP and 3 NP). Motion was recorded using two systems, a 6-sensor accelerometry system and an 8-camera 3-dimensional motion capture system, in order to quantify spatial-temporal, kinematic, and kinetic parameters.

With both systems, participants demonstrated increased stride length and double support and decreased gait speed and cadence WP compared to NP ($p < 0.05$). Also, with motion capture, larger single support time was found WP ($p < 0.05$). With 3-D capture, smaller hip power generation and moments of force were found at heel contact and pre-swing as well as smaller knee power absorption at heel contact, pre-swing, and terminal swing WP compared to NP, when assessed over one cycle ($p < 0.05$). Also, WP yielded smaller moments of force at heel contact and terminal swing along with larger moments at mid-stance of a gait cycle ($p < 0.05$). No changes were found for posture.

NW seems appropriate for promoting a normal gait pattern in older adults. Three-dimensional motion capture should primarily be used during short duration gait analysis (*i.e.* single gait cycle), while accelerometry systems should be primarily employed in instances requiring longer duration analysis such as during the 6MWT.

Video Link

The video component of this article can be found at <https://www.jove.com/video/53926/>

Introduction

Nordic walking (NW) is regarded as a simple and safe form of fitness walking using specially designed poles¹. It is suggested that poles provide added stability, improve posture, and reduce joint stress of the lower extremities. However, limited or contradictory evidence exists regarding joint loading and postural alignment. On one hand, Schwameder *et al.*², Willson *et al.*³, and Koizumi *et al.*⁴ report improvements in kinematic measures and/or reductions in ground reaction, compression, and shear forces with their pole walking studies. On the other hand, declining kinematic measures and increased joint loading in terms of braking/propulsive forces and moments of force have been reported by Hansen *et al.*⁵, Stief *et al.*⁶, and Hagen *et al.*⁷ while pole walking. Additionally, claims of improved postural alignment appear to have gone entirely unsupported by scientific research to this point.

Similar to the contradictory results found with gait patterns, different methods and equipment have been employed in this line of research as well. Several studies have used 3-dimensional motion capture systems^{4,6} and digital video cameras^{2,5}, all with force plates incorporated into the system, in order to adequately assess gait. While additionally, other studies have employed other means of assessing Nordic poling gait including use of electrogoniometry⁷, electromyography (EMG)⁸, and strain gauges mounted to poles^{2,9}. With the technique utilized in this protocol, it presents the specific advantage of being able to demonstrate a more appropriate representation (*i.e.* repeated gait cycles) of an individual's Nordic poling gait over alternative techniques that have focused more on short durations and single gait cycles. Also, this method uses accelerometry, a valid tool, which to this point has been sparsely used in Nordic walking research. Depending on the aim of individual research projects, the application of this protocol may be appropriate for situations as outlined in this protocol, particularly for short and long duration gait. It is important to note that both motion capture and accelerometry are suitable for obtaining a variety of gait characteristics including: spatial-temporal (*e.g.* stride length, gait speed, *etc.*), kinematic (*e.g.* range of motion), and kinetic (*e.g.* forces, power outputs, *etc.*) parameters.

And despite the use of these various pieces of equipment, only short duration gait events (*i.e.* single gait cycle) have been assessed, leaving questions in regards to best assessing longer duration gait (*i.e.* repeated gait cycles). Therefore, the rationale for the development and use of this technique is based upon the importance of fashioning a complete picture of Nordic poling gait.

The purpose of this study was two-fold. First, the primary goal is to determine and substantiate the use of both accelerometry systems and 3-dimensional motion capture systems in the assessment of gait and posture over both short and long durations. Secondly, the goal is to determine the overall effect of Nordic walking poles on gait patterns including spatial-temporal and kinetic measures as well as postural alignment of older adults. To date, minimal research has focused on older adult NW and of that which has been published, function (*i.e.* strength, balance, flexibility) has represented the primary outcome variables. Therefore, knowledge pertaining the role of walking poles on measureable gait variables is needed and can provide insight into how poles can play into our gait patterns as we age.

Protocol

This study was performed in accordance with the guidelines of the Research Ethics Board of the University of Ottawa.

1. Screening Procedure

1. Provide side show presentations to local area walking groups and post recruitment posters at community centers and public facilities in order to recruit a group of active, community-dwelling older adults.
2. Upon initial visit, first greet the participants, introduce them to the laboratory, and provide them time to change into appropriate attire (*i.e.* shorts, t-shirt, and running shoes). Once ready, provide each participant with an in-depth study description, obtain written informed consent, and screen each individual for study eligibility using various questionnaires.
NOTE: Inclusion criteria includes: 55-80 years of age, novice to Nordic walking (NW), no neurological conditions, no cognitive impairments, no cardiac conditions, no previous injury or surgery affecting gait and upper extremity movement, and the ability to walk unaided.
 1. Have the participant complete a General Health and Physical Activity Questionnaire and the Physical Activity Readiness Questionnaire (PAR-Q) in order to confirm age, activity level, any existing neurological conditions, and briefly assess cardiac health.
 2. Next, have them complete a self-reported postural stability and falls questionnaire (adapted from Ashburn *et al.*¹⁰) to determine fall prevalence, if applicable. Lastly, complete the Montreal Cognitive Assessment (MOCA) with each subject in order to control for mild cognitive impairment¹¹, constituting a minimum score of 26 out of 30.

2. Pole Set-up and Nordic Walking Instruction

1. Provide each participant with a set of poles, and instruct them on how to adjust the poles to an optimal length relative to their height. Ensure that the adjustment corresponds to approximately 65% of the individual's body height.
 1. Provide each participant with the following instructions regarding pole adjustment. Ask the participants to stand tall, have the participants place the pole tip in front of the toes, instruct the participants to place the elbow and forearm next to the body, and ask the participants to lengthen the poles so the elbow forms an approximate 90° angle next to the body. Finally, securely tighten the poles and angle the boot tips backwards.
2. Instruct the participant the following 4 basic steps in order to minimize the amount of information to process and ensure a thorough understanding of technique¹². Allot approximately 30 min for instruction and subsequent practice of the technique.
NOTE: Nordic walking instructions are to be given by a certified Nordic pole walking instructor.
 1. Before securing the wrist straps, instruct the participant to place their poles behind the lower back and stand tall. Ask the participants to stand with their chest tall and the shoulders relaxed.
NOTE: Explain to the participant that this is done to gain an understanding of the required upright body posture for Nordic walking.
 2. Have each participant secure the wrist straps, place the pole tips behind them, and relax their arms at their sides. While keeping their hands open (*i.e.* not grasping handles), instruct the subject to begin walking with minimal arm swing for approximately 100 m.
NOTE: At this stage, the poles are simply trailing behind the participant.
 3. While still keeping the hands open and dragging the poles behind them, instruct the participant to begin walking faster. Ask the participants to visualize bringing their hand up as if they are about to shake someone's hand.
NOTE: At this phase, explain that the goal is to promote the natural reciprocal and rhythmic actions of the arms and legs during gait.
 4. Finally, as the arm swings forward, have the participant gently grasp the handle and apply a force against the ground. With each arm swing, instruct the individual to slightly lift the poles off the ground and firmly plant them with each subsequent stride.
NOTE: At this stage, explain that the applied force aids in progression of gait and provides resistance to the upper body musculature.

3. Data Collection and Testing Protocol

1. Using a standard tape measure, weight scale, and caliper, take the participant's anthropometric measurements, including height, weight, inter-ASIS distance, left and right leg lengths, knee widths, ankle widths, shoulder offsets, elbow widths, wrist widths, and hand thicknesses.
 1. Using a tape measure, measure each leg length as the distance from the anterior-superior iliac spine (ASIS) to the center of the medial malleolus as well as the distance between the left and right ASIS (*i.e.* inter-ASIS distance).
 1. Next, measure the widths of each joint using a caliper by finding the distance between the bony prominences (*e.g.* condyles) of each joint. Lastly, measure the height and weight of the participant using a standard tape measure and scale, respectively.

2. In order to assess gait patterns (e.g. spatial-temporal measures) and postural alignment over a long period of time, use an accelerometry system for data collection during the 6 Minute Walk Test (6MWT), which is a valid and appropriate test in the assessment of older adult physical endurance¹³.
 1. For the accelerometry system, ensure that it is comprised of at least 6 sensors, each with accelerometers and gyroscopes incorporated into them in order to measure both the acceleration (g) and angular velocity (deg/sec) of each specific body segment.
 1. Prior to placement on the participant, ensure that all sensors are securely docked to the system's docking station in order to synchronize them and calibrate the system, and ultimately relay precise data measurements¹⁴.
 2. Attach the sensors using adjustable hook and loop straps, secure the sensors to the wrists, ankles, lumbar spine (L5) and trunk and collect at a sampling rate of a minimum of 100 Hz.
 1. When placing the sensors, ensure that they are oriented according to the system guidelines. Position the ankle sensors anteriorly. Position the wrist sensors posteriorly (when in anatomical position). Position the trunk sensor atop the sternum, and position the L5 sensor directly at the L5 vertebrae.
NOTE: Kinematic data is wirelessly transmitted from these sensors to an access point, which is used to precisely time the transmission of the synchronized data.
 3. Fit the participant with the 6 sensors and ask them to perform two trials of the 6MWT, one with poles and one without. Randomly assign these two trials to control for order effect.
 4. Instruct the participant to walk back and forth along a 25 m walkway at a self-selected speed for the 6MWT, for both with and without poles. At this time, be sure to click 'Start' to begin data collection with the accelerometry system.
NOTE: During pole trials, provide further instruction to the participant to implement their poling instruction.
3. Finally, assess short duration gait events using a 3-dimensional motion capture system collecting at a minimum of 100 Hz, with two force plates embedded in the pathway. Synchronize the force platforms with the motion capture system, ensure that the force platforms are zeroed to prevent noise in the data, and ensure that they are collecting at a sufficient sampling rate, for example 1,000 Hz.
 1. Synchronize the force plates to the motion capture system by first connecting them to the computer via the wires provided from the company. Second, directly within the motion capture system software, it is imperative to 'add' the force plates to the capture volume by entering the dimensions, sensitivities, sampling rates, and any other required information for the system.
 2. Ensure that the force plates have been 'zeroed'. Do this in two steps: 1) right click on each force plate within the software and select 'Zero force plate' and 2) press the 'zero' button that is directly on the data acquisition box of the force plates.
NOTE: Ensure that the motion capture system collects real-time information from both the left and right legs from foot strikes on each force platform and allows for spatial-temporal, kinematic, and kinetic analysis.
4. Complete a dynamic calibration of the system (aimed at defining the capture volume that is to be used during data collection). To do this, wave a 3-marker wand in a controlled manner through the capture space. Then perform a static calibration of the system to set the global coordinate system (i.e. reference point of 0, 0, 0 (x, y, z) by placing a 4-marker L-frame at that specified reference point and select 'Set Volume' within the computer software.
NOTE: The dynamic calibration later assists in the reconstruction of the 3-dimensional position of 39 reflective markers used for this model.
 1. Fit the participant with the 39 reflective markers, attaching them using double-sided tape and placing them on specific anatomical landmarks including: second metatarsals, lateral malleoli, calcanei, left and right mid-shank, lateral femoral condyles, left and right mid-thigh, ASIS, PSIS, T10, C7, right back, clavicle, sternum, acromion processes, left and right mid-humerus, lateral epicondyles, left and right mid-forearm, medial and lateral wrists, second metacarpals, anterior-lateral head, and posterior-lateral head.
 2. Instruct the participant to then perform 6 trials of a 5 m walk through the systems capture volume, three with poles and three without. Randomly assign these trials to control for order effect and provide the same instruction as per the 6MWT.

4. Data and Statistical Analysis¹⁴

1. During analysis of the 6MWT, remove all turns during the trial in order to account for strictly steady state walking. After removing the turns, use the system software to extract the spatial-temporal measures, trunk range of motion (ROM) in all places, and trunk velocities in all planes.
NOTE: This is done automatically during this protocol through algorithms used by the system itself¹⁴. The steps to extract the necessary dependent variables within this system are listed below.
 1. Using the accelerometry system software, first click on 'Monitor Data', select the appropriate time stamped trials that have been collected, right click on the trials, and select 'Convert to CSV'. After doing this, open the CSV file and ensure that data from all 6 sensors has been exported for further analysis.
 2. Next, select the trial again and click 'Export to PDF'. Observe the system generate a PDF report with a number of variables. From here, extract variables that are desired for the study, in this case, spatial-temporal and kinematic measures.
2. For 3-dimensional motion capture, filter all trials using a fourth-order zero lag Butterworth filter for analog devices with a cut-off frequency of 10 Hz as well as a Woltring filter for the marker trajectories with a 15 mm MSE predicted value. To do this, attach the 'Butterworth and Woltring' filtering options to the operations pipeline within the system software, select the aforementioned cut-off frequencies and MSE values, and click 'Run'.
 1. Add an 'Export to ASCII file' operation to the operations pipeline within the system and select 'Run'. Save the newly exported ASCII (spreadsheet) worksheet to the computer.
 2. Open the exported ASCII files and within each file, locate the power outputs and moments of force (i.e. kinetics) for each of the lower extremity joints, including the ankle, knee, and hip.
NOTE: Using the minimum and maximum functions within the worksheet, calculate the upper and lower peaks corresponding to the different phases of a single gait cycle (e.g. A1, K1, H1, etc.) as outlined by Winter¹⁴.

3. Next, extract the spatial-temporal measures using the specific system software, which in this instance, is automatically calculated through system algorithms and from anthropometric measurements. To extract the specific variables, first import the desired trial into the system software, select 'Events', and click on the desired variable to obtain the variable average from each trial.
3. Lastly, using the ASCII files, locate the trajectories for the C7 marker as well as the sacral/pelvic markers. Using these trajectories, calculate postural alignment as the differential between these markers and trajectories in both the medial-lateral and anterior-posterior directions.
4. Open statistical software and import the specific trial. First, using Shapiro-Wilks test for normality, ensure whether data is normally distributed.
 1. To compare with and without poles, use paired t-tests when data is normally distributed and Wilcoxon Signed Rank Tests when skewed. Use Holm-Sidak multiple pairwise comparison procedures when necessary. Significance level is set at $p < 0.05$.

Representative Results

Spatial-Temporal Gait Parameters

When walking with Nordic walking poles and assessed using motion capture and force plates, stride length ($p < 0.01$), double support time ($p < 0.001$), and single support time ($p < 0.001$) are all significantly longer compared to walking without poles. In addition, gait speed ($p < 0.05$) is significantly slower and cadence ($p < 0.001$) is significantly smaller with poles compared to without in older adults. Further, when examining gait over a longer duration walk with the 6MWT and using accelerometry, similar results are noted with a longer stride length ($p < 0.001$) and double support time ($p < 0.001$) as well as a significantly slower gait speed ($p < 0.001$) and smaller cadence ($p < 0.001$) (**Table 1**).

Lower Extremity Joint Kinetic Analysis

Kinetic measures are solely assessed using 3-dimensional motion capture.

Hip Joint

When using poles, significantly smaller hip power generation is seen at heel contact (H1) ($p < 0.05$) as well as at pre-swing (H3) ($p < 0.01$) compared to walking without poles (**Figure 1**). To coincide with these reductions in hip power generation, the moment of force while walking with poles is significantly smaller at both heel contact ($p < 0.05$) and pre-swing ($p < 0.05$) compared to without poles.

Knee Power Generation/Absorption

When using poles, significantly smaller knee power absorption is seen at heel contact (K1) ($p < 0.05$), at pre-swing (K3) ($p < 0.001$), and at terminal swing (K4) ($p < 0.001$) compared to walking without poles (**Figure 2**). Additionally, with poles significantly smaller moments of force are found at heel contact ($p < 0.001$) and at terminal swing ($p < 0.001$) and significantly larger moments of force at mid-stance ($p < 0.01$) compared to without poles.

Ankle Power Generation/Absorption

There are no significant power output or moment of force differences at the ankle joint at either heel contact (A1) or toe-off (A2).

Postural Analysis

There are no significant differences in trunk range of motion when using accelerometry in any of the three planes of motion (*i.e.* frontal, sagittal, and horizontal) or with motion capture in the frontal and sagittal planes.

The results found in this research coincide with previous research on the same topic using similar motion capture systems. These results demonstrate that this technique and use of both motion capture and accelerometry can be widely appropriate in the assessment of gait and posture.

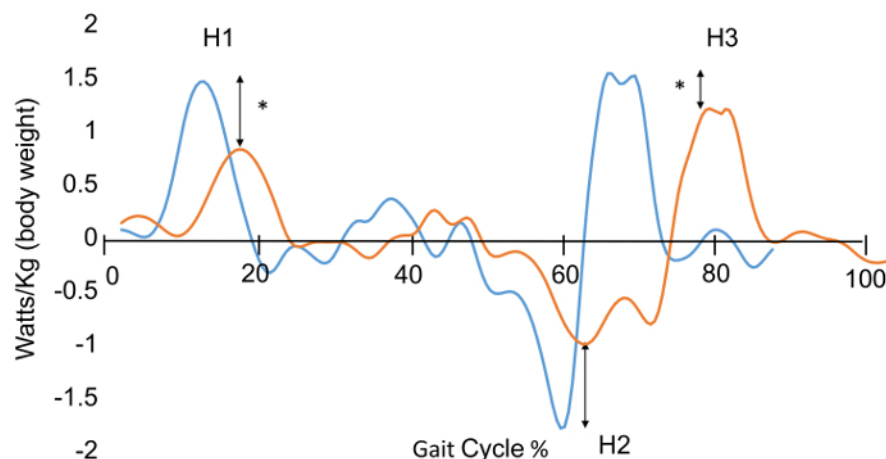


Figure 1: Peak hip power over a single gait cycle. This figure represents a typical hip power profile in watts per kilogram of body weight over one single gait cycle (*i.e.* heel strike of one foot to the next heel strike of that same foot) to compare with poles (Red) to without poles (Blue). The arrows at H1, H2, and H3 phases are indicative of the changes in power generation/absorption in comparing with poles to without poles, with the asterisks indicating a significant difference between the two. [Please click here to view a larger version of this figure.](#)

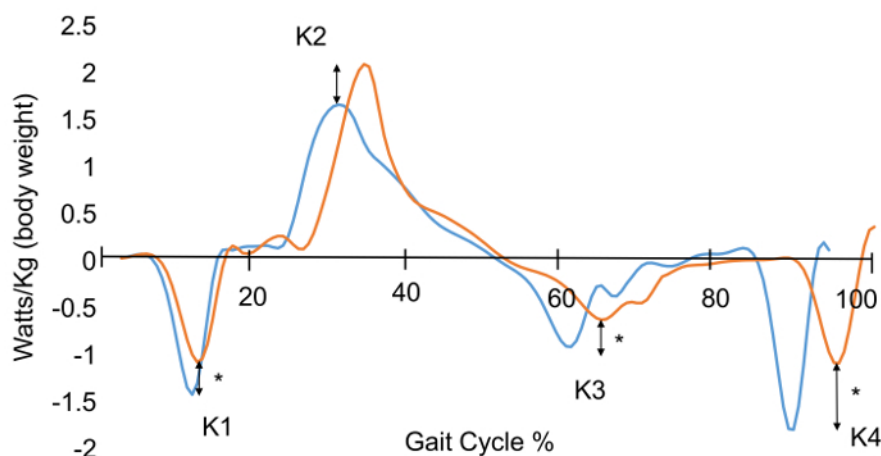


Figure 2: Peak knee power over a single gait cycle. This figure represents a typical knee power profile in watts per kilogram of body weight over one single gait cycle (*i.e.* heel strike of one foot to the next heel strike of that same foot) to compare with poles (Red) to without poles (Blue). The arrows at K1, K2, K3, and K4 phases are indicative of the changes in power generation/absorption in comparing with poles to without poles, with the asterisks indicating a significant difference between the two. [Please click here to view a larger version of this figure.](#)

	VICON		APDM	
	With Poles	Without Poles	With Poles	Without Poles
Outcome Measures	Mean $\pm$ SD			
Stride Length (m)	1.39 $\pm$ 0.19	1.31 $\pm$ 0.21 †	1.47 $\pm$ 0.11	1.42 $\pm$ 0.11 †
Gait Speed (m/sec)	1.08 $\pm$ 0.23	1.18 $\pm$ 0.20 *	1.25 $\pm$ 0.17	1.39 $\pm$ 0.14 †
Cadence (steps/min)	93.07 $\pm$ 10.90	108.78 $\pm$ 11.26 †	101.92 $\pm$ 12.17	117.82 $\pm$ 9.74 †
Double Support Time (sec)	0.34 $\pm$ 0.06	0.28 $\pm$ 0.06 †	0.28 $\pm$ 0.07	0.22 $\pm$ 0.06 †
Single Support Time (sec)	0.48 $\pm$ 0.05	0.41 $\pm$ 0.04 †	---	---

Table 1: Spatial-temporal means and standard deviation for both data collection systems. This table represents the various spatial-temporal measures obtained from both accelerometry and motion capture systems. Both crosses and asterisks represent a significant difference between with poles and without poles for each respective system, with crosses specifically representing significant difference at $p < 0.01$ and asterisks representing a significant difference at $p < 0.05$.

Discussion

The importance of maintaining consistency in terms of pole use is critical within this protocol. Particularly, appropriate steps for proper poling technique as well as proper pole set up are important to maintain consistency across different studies. Therefore the guidelines and instructions of a specific Nordic walking organization should be adhered to for protocols such as this. Additionally and particularly when using accelerometry, use of a full body set of tri-axial monitors is important to obtain a complete understanding of the subject's full body motion (e.g. gait and posture) including acceleration and rotation of each specific body segment. Such a system can and should be primarily employed in instances as per this protocol, using a relatively long walkway (e.g. 25 m) in order to account for long duration events as well as minimize the number of turns to account for primarily steady state walking. This could be particularly important when using validated gait tests such as the 6MWT¹³ within both clinical and research settings.

Further, motion capture systems have been reported as appropriate equipment in studying short duration events such as single gait cycles¹⁶ and should be used as such, as is the case with the second portion of this protocol. To ensure accuracy of this system, it is imperative to perform proper static and dynamic calibrations of the system to set the capture volume and more importantly the global coordinate system required for 3-dimensional reconstruction of the reflective markers. In order to assess both gait as well as postural alignment, a full body marker set (e.g. Plug-in Gait model) is necessary as the positions and displacements of the hip (PSIS and Sacral) and spinal (C7) markers are critical in the analysis and measurement of trunk range of motion (ROM) in the anterior-posterior (AP) and medial-lateral (ML) directions. And lastly, the forces plates integrated with the system should be collecting at a sufficient sampling rate, for instance, 1,000 Hz from this protocol. Sampling rate can be changed from study to study, however, researchers must be certain not to violate the Sampling Theorem, which states "the process signal must be sampled at a frequency at least twice as high as the highest frequency present in the signal itself"¹⁷.

Depending on equipment availability within different laboratory setting, various accelerometry systems and motion capture systems may be used, provided they allow for adherence to the critical steps of this protocol. For example, if unable to use a tri-axial monitor system that has both acceleration and gyroscope readings or if the lab space is insufficient to incorporate a long walkway, use of this system may not be entirely adequate for the assessment of one's gait and posture. Similarly, with motion capture systems, use of a lower-body model for each participant is adequate in the assessment of various gait characteristics, however, lower-body models would fail to appropriately assess postural alignment as some of the necessary hip and spinal markers may be missing to calculate trunk ROM. Also, if using this protocol to examine specific conditions (e.g. knee osteoarthritis or ACL injury), use of different or modified marker sets such as that used by Ali, Rouhi, and Robertson¹⁸ may be used to create a more complete assessment of the knee for such conditions. Additionally, as this study is focused on older adults only, the protocol can benefit from the addition of a control group for comparison purposes, however, this is largely dependent on the populations for each individual study. Depending on the population, a control group (e.g. young adults) may contribute to further understanding how gait and postural alignment changes, both with and without the use of Nordic poles. Also, to better understand the role that the poles themselves play during gait, use of strain gauges could be incorporated. Following a technique previously used on healthy young adults by Jensen and colleagues⁹, placement of a strain gauge on each of the poles could assist in the assessment of kinetic gait measurements. And lastly, following a technique employed by Shim and colleagues⁸, using electromyography (EMG) with this protocol can aid in understanding the specific muscle activation patterns of both the upper and lower extremities during Nordic walking.

The originality of this protocol resides in the fact that it provides the guideline for state of the art gait analyses in two very different set-ups. Therefore, this gives rational and viable options for researchers and clinicians to choose from when deciding on the protocol that will serve best the purpose of their analysis. To reiterate, with the 3-dimensional motion capture system, the goal is to study short duration events as is the case with a single gait cycle, while accelerometer systems are used in this instance to study gait as a whole over a longer period of time. Different 3-dimensional motion capture systems as well as video cameras, all with force plates integrated into them have been commonly used in the assessment of Nordic walking gait³⁻⁶. Stief *et al.*⁶ used a 6-camera system to collect 5 poling and 5 non-poling trials in order to measure the kinematics (i.e. ROM) and kinetics (i.e. moments of force) about the hip, knee, and ankle joints. Similarly, a 10-camera system was used by Koizumi *et al.*⁴ with two force plates incorporated into it to obtain kinetic measurements from 10 Nordic walking trials in order to ultimately calculate shear and compression forces of the lower extremity joints and lumbar spine. Further, Hansen *et al.*⁵ used a 5-camera digital video system to record movements, again with two force platforms embedded in the walkway in order to quantify kinetic variables including: compression forces, shear forces, ground reaction forces, and moments of force. Existing methods fundamentally point to the use of motion capture systems as widely accepted and largely appropriate for an accurate and efficient measure of an individual's gait patterns, albeit for short duration events.

Contrary to the commonality of motion capture, alternative methods such as the one used by Hagen *et al.*⁷ have at times been employed. In this particular study, electrogoniometry and force plates are used to evaluate the spatial-temporal measures (e.g. stride length), lower extremity ROM, and kinetics, specifically the vertical force. They did also use an accelerometry system, however, it is a uniaxial monitor that was only placed on the right radial side of the wrist to measure wrist acceleration and assist in estimation of shock to the body. Beyond Hagen *et al.*⁷ in recent years, Nordic walking gait has really yet to be examined using accelerometry. And further yet, research has yet to study longer duration gait events such as with the 6MWT. Just as motion capture is widely used for short duration events, accelerometry should become more of a staple in gait analysis, particularly over a lengthier period of time. If use of accelerometry is more widely recognized and valued in this respect, this may allow for a more representative evaluation of gait as it is performed on a daily basis.

Once the protocol is perfected, using both accelerometry and motion capture for Nordic poling gait analysis will help to create an assessment of gait in its entirety that could be representative of both short spurts of walking as well as longer. Moreover, such techniques may be employed with specific populations (e.g. Parkinson's disease) to gain a better understanding of how Nordic walking poles can affect not only a single stride, but also obtain a better representation of their gait from repeated strides. Also, if available in clinical practice, clinicians may be able to use accelerometry to more precisely measure a patient's gait during clinical assessment. Such systems are particularly user friendly and simplify data collection and analysis. Finally, looking at the effect of a Nordic walking intervention may be appropriate to coincide with this protocol. It is possible that learning the poling technique and then instantly performing laboratory testing may not result in an entirely accurate assessment.

Instead, practice with the poles for a period of time (e.g. 8 weeks) may provide a better assessment of the effect of Nordic poles on gait and posture.

Disclosures

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