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Title: Comparison of Step-Based Metrics Under Laboratory and Free-Living Conditions in Femoroacetabular Impingement Syndrome

Naif Z. Alrashdi, PT, MSRS, PhD[1]; Elroy J. Aguiar, PhD[2]; Collin E. White[3]; Anna K. Saunders[3]; Amit M. Momaya, MD[4]; Benton A. Emblom, MD[5.6]; Michael K. Ryan, MD[5,6]; Robert W. Motl, PhD[7]; Matthew P. Ithurburn, PT, DPT, PhD[6,8]

1. Department of Physical Therapy and Health Rehabilitation, College of Applied Medical Sciences, Majmaah University, Al-Majmaah, 11952, Saudi Arabia (n.alrashedy@mu.edu.sa)
2. Department of Kinesiology, The University of Alabama, Tuscaloosa, AL, United States (ejaguiar@ua.edu)
3. Doctor of Physical Therapy Program, School of Health Professions, University of Alabama at Birmingham, Birmingham, AL, United States (cwhite94@uab.edu and aks26@uab.edu)
4. Department of Orthopaedic Surgery, School of Medicine, University of Alabama at Birmingham, Birmingham, AL, United States (amit.momaya@gmail.com)
5. The Hip Center at Andrews Sports Medicine and Orthopaedic Center, Birmingham, AL, United States (Benton.Emblom@andrewssm.com and mkryanmd@gmail.com)
6. American Sports Medicine Institute, Birmingham, AL, United States (Benton.Emblom@andrewssm.com; mkryanmd@gmail.com; matti@asmi.org)
7. Department of Kinesiology and Nutrition, University of Illinois Chicago, Chicago, IL, United States (robmotl@uic.edu)
8. Department of Physical Therapy, University of Alabama at Birmingham, Birmingham, AL, United States (matti@asmi.org)

Corresponding author:

Naif Alrashdi, PT, MSRS, PhD; Assistant Professor, Department of Physical Therapy and Health Rehabilitation, College of Applied Medical Science, Majmaah University, 11952, Riyadh, Saudi Arabia; n.alrashedy@mu.edu.sa

Conflict of Interests

We have no conflict of interest to disclose.

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Twitter Handles:

Naif Alrashdi: @Naifz2ma
Elroy Aguiar: @ElroyAguiar
Amit Momaya: @AmitMomayaMD
Benton Emblom: @BentonEmblomMD
Michael Ryan: @MKRMD
Matthew Ithurburn: @MattIthurburnPT

Comparison of Step-Based Metrics Under Laboratory and Free-Living Conditions in Femoroacetabular Impingement Syndrome

Abstract

Context: Femoroacetabular impingement syndrome (FAIS) causes pain and functional limitations. Little is known regarding walking characteristics, volume and intensity evaluated in laboratory and free-living conditions and whether these measures differ between those with FAIS and uninjured individuals.

Objective: To examine the differences in laboratory gait measures and free-living step-based metrics between individuals with FAIS and uninjured control participants.

Design: Comparative, cross-sectional study

Patients or Other Participants: We enrolled 25 participants with FAIS and 14 uninjured controls

Main Outcome Measures: We evaluated laboratory spatiotemporal gait measures (cadence, velocity, step length, stride length) during self-selected and fast walking speeds using an instrumented walkway. Participants then wore an accelerometer around the waist during waking hours for 7 consecutive days. Free-living step-based metrics included average daily steps, peak 1- and 30-minute cadence, and average daily time spent in walking cadence bands. We compared laboratory gait measures and step-based metrics between groups.

Results: The groups did not differ in laboratory spatiotemporal gait measures during both speeds (all $p>0.05$). The FAIS group took fewer daily steps (5,346±2,141 vs. 7,338±2,787 steps/day; $p=0.030$) and had a lower peak 1-minute (92.9±23.9 vs. 119.6±16.3 steps/min; $p<0.001$) and 30-minute cadences (60.9±27.1 vs. 86.8±22.4 steps/min; $p=0.003$) compared with uninjured controls, respectively. The FAIS group also spent less time in slow (6.0±3.6 vs. 10.3±3.4 min/day; *p*=0.001), medium (4.5+4.2 vs. 8.9±4.4 min/day; *p*=0.005), and brisk/moderate (4.5±6.2 vs. 12.2±10.3; *p*=0.020) cadence bands compared with uninjured controls.

Conclusions: Considering only clinical/laboratory gait measures may not be representative of real-world walking-related PA behavior in individuals with FAIS.

Key Words:

Cadence, physical activity, FAIS, hip morphology

Abstract Word Count: 251

Key Points:

1. Individuals with FAIS took fewer daily steps, had a lower peak 1-minute and 30-minute walking cadence, and spent less time in faster rates of walking-related movement compared with controls.
2. Considering only clinical/laboratory gait measures may not be representative of real-world walking-related PA behavior in individuals with FAIS or in other musculoskeletal pain conditions.

INTRODUCTION

Femoroacetabular impingement syndrome (FAIS) is a pre-arthritic hip disorder characterized by bony morphology of the femoral head/neck (cam-type), the acetabulum (pincer-type), or in some cases, both (mixed-type).[1] This abnormal overgrowth of bone may lead to unbalanced force distribution in the hip joint that is thought to cause intra-articular injuries to the labrum and cartilage.[2-6] Individuals with FAIS often report hip pain,[1,7,8] limited hip-related function,[9-11] and poor quality-of-life,[8,9,12] and are at risk for developing early-onset hip osteoarthritis over time.[13,14] Importantly, regarding free-living function and activity, recent studies have reported that individuals with FAIS were less active than their peers,[10,11,15,16] and walked at slower speeds during laboratory-measured gait testing compared with healthy individuals.[17]

Across various patient populations, slow walking speed has been associated with disability, mortality, and other comorbidities (e.g., heart disease).[18,19] Cadence, or the number of steps an individual takes per minute, is a simple measure of gait function and physical activity that has wide appeal for researchers, clinicians, and the public.[20-22] Cadence can be measured using overground devices (e.g., gait mats) in controlled (laboratory) environments or using wearable technologies (e.g., fitness trackers and accelerometers) in uncontrolled (free-living) environments and provides a unique approach for determining an individual's physical activity and walking-related intensity.[23] Currently, little is known regarding walking characteristics, volume, and intensity evaluated in both laboratory and free-living conditions and whether these measures differ between those with FAIS and uninjured individuals. We are aware of only one study that has evaluated minute-by-minute time spent at varying stride frequencies (i.e., percent of time spent in no activity, low activity, medium activity, and high activity) between individuals with FAIS and healthy control participants.[15] That study reported no differences in the percentage of time spent across stride frequencies between those with FAIS and healthy controls.[15] Further investigation is required to more comprehensively assess walking-related behavior using pragmatic approaches in a manner that considers both volume (e.g., steps/day) and stepping pattern/intensity (e.g., step-based metrics) under free-living conditions. Such findings could provide insight into how daily walking behavior is affected in those with FAIS; potentially providing critical markers of disease progression, recovery following treatment, and/or long-term joint health in this population. Additionally, clinical interventions could be developed to target free-living physical activity and walking behavior most affected in those with FAIS.

In this study, we compared laboratory gait measures (cadence, gait velocity, step length, and stride length) and free-living step-based metrics (daily steps; peak 1-minute and 30-minute cadence; and time spent in cadence bands) between individuals with FAIS and uninjured controls. We hypothesized that individuals with FAIS would demonstrate reduced spatiotemporal gait outcomes during laboratory-measured gait testing, take fewer daily steps, demonstrate lower peak 1-minute and 30-minute walking cadence, and spend less time at higher paced/intensity walking than uninjured control participants.

METHODS

Participants

We enrolled two groups, individuals with FAIS and uninjured control participants. Individuals with a diagnosis of FAIS were recruited from the practice of two clinical collaborators (XXX; XXX) at XXX and XXX, respectively. Diagnosis of FAIS followed the Warwick Agreement (2016) consensus recommendations,[1] including a combination of the following diagnostic criteria: 1) radiographic signs of impingement-related bony morphology (e.g., cam, pincer, or mixed); 2) positive clinical findings (e.g., painful hip range of motion or positive intra-articular provocation tests); and 3) reporting associated symptoms (groin/hip pain or stiffness).[1] We enrolled uninjured control participants who reported no history of groin/hip pain or major lower extremity injury/surgery (we included those with 2 or fewer lateral ankle sprains), and spine surgery from the local community via flyers and word of mouth. We performed a screening phone call with potential participants prior to enrollment, and we excluded both individuals with FAIS and potential control participants if they reported that they had been diagnosed with hip osteoarthritis, if diagnosed with osteopenia/osteoporosis, or if currently pregnant. Before enrolling in the study, we required all participants (FAIS and controls) to be actively engaged in a purposeful activity greater than 50 hours/year (or to have been prior to the onset of hip/groin pain for those with FAIS).[24-26] We obtained institutional review board approval for the study prior to initiation (IRB approval #XXXXX), and all participants provided written, informed consent prior to participating.

Laboratory Assessments and Prior Activity Levels

Standard demographic and anthropometric data were collected, including age, sex, and body mass index (BMI). Physical activity levels before enrolling in our study was evaluated in the FAIS and uninjured control participants using the International Physical Activity Questionnaire short form (IPAQ).[27] The IPAQ is a valid, reliable, and widely used tool for evaluating self-reported activity in the previous 7 days.[27] We measured spatiotemporal gait parameters in all participants using a GAITRite® PLATINUM PLUS CLASSIC walkway (GAITRite; Franklin, NJ). The GAITRite is a portable pressure-sensitive electronic walkway used to evaluate gait, and provides fast, clinically-relevant measures to identify gait abnormalities.[28] It has been used across various patient populations, including in studies of those with total hip arthroplasty.[29] We assessed cadence (steps/minute), gait velocity (m/s), step length (cm), and stride length (cm) in all participants, during both a self-selected preferred and fastest (maximum) walking speed (2 trials at each speed). For the self-selected trials, we instructed participants to walk at a speed that they would use to purposefully go from one place to another. For the fastest walking speed, we instructed participants to walk as fast as possible without jogging or running. We used the software associated with the GAITRite to calculate average values (involved and uninvolved limbs for FAIS; right and left limbs for controls) over the 2 trials at both speeds for the aforementioned variables.

Free-Living Step-based Metrics Assessment

Following the laboratory visit, we provided all participants a waist-worn accelerometer (ActiGraph GT3X+, Pensacola, FL) to wear for 7 consecutive days on an elastic belt (above the non-painful hip for FAIS group; above the non-dominant hip for the control group[10,11]). We instructed participants to wear the accelerometer from when they awoke in the morning throughout the entire day, and to take it off only when sleeping or during water-based activities such as swimming or showering. We provided participants a daily log sheet to record the time they put the accelerometer on, the time they took it off, and any time during the day that the accelerometer was not worn. Accelerometers were initialized to collect continuous data at 100 Hz and summarized in in 1-minute epochs.[30] We downloaded and processed the accelerometry data using the Troiano wear-time algorithm[31], and ActiGraph's proprietary step algorithm in the ActiLife software (version 6.13.3). The final dataset included data from participants with valid wear time (≥8 h of daily wear time for ≥ 4 valid days).[32]

Accelerometry data were further processed using a custom function in R (step_metrics; *https://github.com/jhmigueles/step_metrics*) to produce three step-based metrics: 1) daily step counts (steps/day); 2) peak 1-minute cadence (steps/min); and 3) peak 30-minute cadence (steps/min). Peak 1-minute cadence summarizes an individual's highest minute of walking (best effort/pace in term of steps/min) within a day, averaged across all valid wear days. Peak 1-minute cadence values can be interpreted as an indicator of both functional capacity and behavioral decision to walk at higher/faster rates of movement.[33-35] Peak 30-minute cadence summarizes the highest 30 minutes (not necessarily consecutive) of activity within a day, averaged across all valid wear days. Peak 30-minute cadence reflects both the intensity and persistence of stepping behavior performed by individuals within and across days.[34,36-38] Additionally, the step-metrics function calculates time spent (minutes) within cadence bands, including non-movement (zero cadence), incidental movement (1-19 steps/min), sporadic movement (20-39 steps/min), purposeful movement (40-59 steps/min), slow walking (60-79 steps/min), medium walking (80-99 steps/min), brisk/moderate waking (100-119 steps/min), and faster walking (≥120 steps/min),[39,40], averaged across valid days.

Statistical Analyses

We compared demographic and anthropometric characteristics, IPAQ scores, laboratory spatiotemporal gait assessment (cadence, velocity, step length, stride length), step-based metrics (daily steps, peak 1-minute and 30-minute walking cadence), and time spent in various cadence bands between the FAIS and control groups using independent sample *t*-tests (assumptions for *t*-tests were met). Cohen's *d* effect sizes were calculated and interpreted as: 0.2 small, 0.5 medium, 0.8 large.[41] We used the Statistical Package for the Social Sciences (SPSS, V.27) for all statistical analyses, and a significance level was set a priori (a<0.05).

RESULTS

Demographic and anthropometric data for the groups are shown in Table 1. There were no significant differences in age, sex distribution, body mass index (BMI), IPAQ scores, or accelerometer wear time between FAIS and uninjured control participants (**Table 1**; all p>0.05). Descriptive data for gait cadence, velocity, step length, and stride length during self-selected and fast walking speeds are shown for the groups in **Table 2**. Although the laboratory gait-related variables were not statistically different (all p>0.05), we did observe small to medium effect sizes (d=0.2 to 0.7). In particular, the FAIS group displayed lower cadence values during both the preferred and fast walking trials compared to controls.

There were significant differences in daily steps, peak 1-minute cadence, and 30-minute cadence between individuals with FAIS and uninjured control participants, with lower values observed for the FAIS group (Figures 1A, B, and C). Additionally, there were significant differences in average time (minutes) spent in slow walking, medium walking, and brisk/moderate walking between individuals with FAIS and uninured control participants, with lower values observed for the FAIS group (Figures 2E, F, and G). No other significant group differences were found in the remaining cadence bands (all p values >0.05; Figures 2A, B, C, D, and H). Descriptive data for daily steps, peak 1-minute and 30-minute cadence, and time spent in each cadence bands for both groups are presented in Table 3 (Supplemental).

DISCUSSION

Our main findings indicated that individuals with FAIS had significantly lower average daily steps, peak 1-minute and 30-minute walking cadence, and spent fewer minutes in slow, medium, and brisk walking paces/intensities compared with uninjured controls. In contrast, laboratory measured spatiotemporal parameters during self-selected and fast walking were not statistically different.

We hypothesized that there would be differences in spatiotemporal gait measures when comparing groups due to hip pain, limited hip range of motion, and/or patient reported symptoms that commonly associate with FAIS.[1] The FAIS group displayed a lower cadence during the preferred (p=0.077, d=0.7, Table 2) and fast walking trials (p=0.239, d=0.4, Table 2). However, these differences were not statistically significant despite a small to moderate between group effect sizes. Two previous studies have evaluated laboratory-measured gait speed, cadence, step length, and stride length in those with FAIS and ininjured control participants.[17,42] The first study reported that controls demonstrated significantly higher gait speed and cadence compared to FAIS individuals.[17] Notably, they reported gait parameters for the painful/involved limb within the FAIS group, whereas we report gait parameters based on the average value for involved and uninvolved limbs.[17] The second study reported no significant differences in laboratory gait measures between those with FAIS and controls, consistent with our laboratory gait-related findings.[42] In our study, we used a GaitRite walking mat to evaluate our laboratory gait measures, whereas both of these other previous studies[17,42] used a three-dimensional motion capture system to evaluate laboratory gait measures. Differences in the accuracy of the measurement approach and the calculation of the specific laboratory gait-related measures, might explain, at least in part, the differences between our findings and that of previous studies.

When comparing free-living PA using step-based metrics, we observed significant differences in volume and peak metrics between the groups (Figures 1 and 2; see Supplement for detailed descriptive data). Specifically, average daily steps, peak 1-minute and peak 30-minute cadence were all higher in the healthy control group as compared to the FAIS group. Our findings regarding daily steps between individuals with FAIS and healthy controls were different from two previous published studies.[11,15] Whereas prior research found that those with FAIS demonstrate lower device-mesured physical activity (general activity measured by volume and intensity[10,11,15,16]), two preior studies specifically evaluating step counts reported no significant difference between those with FAIS and healthy controls.[11,15] Regarding time spent in various cadence bands, uninjured controls and FAIS did not differ in time spent in non-movement, incidental movement, sporadic movement, and purposeful walking. Notably, however, the uninured control group spent more time in slow walking, medium walking, and brisk walking compared with the FAIS group. This is in contrast to a previous study (n=74) that reported no significant differences in the percentage of time spent in various stride frequency bands in those with FAIS compared with healthy control participants.[15]

Several methodological aspects could explain the inconsistencies between our findings and previously published work regarding walking-related activity measures in those with FAIS in comparison to uninjured control participants. In our study, we recorded daily activity using an accelerometer over 7 days, including weekdays and weekends, where activity patterns might be different.[43] Additionally, we used a waist-worn accelerometer placement that is more convenient for the participant and associated with better wear-time compliance.[44] Previous studies employed different methods to quantify activity.[11,15] For example, one study recorded daily activity only over 5 days and used a thigh-worn accelerometer, and did not specify whether weekday and/or weekend days were included.[11] Widely-accepted best practice is to measure physical activity over 7 days to capture sufficient variability in estimating average daily activity,[45,46] and the average valid wear days were 6.2 and 6.6 days for the FAIS and control groups in our cohort, respectively. The other study that recorded daily activity for a 7-day period used a step-watch, an ankle-worn device.[15] Previous studies have reported differences between step-count estimate for the ankle-worn, thigh-worn, and waist-worn devices based on proximity to the foot.[47] In our study, we included participants (FAIS and controls) with similar demographic and anthropometric data (no significant differences between groups), however, both of the previously-published studies included participants (FAIS and controls) with a various range of age, sex, and BMI (FAIS were significantly different in demographic data in comparison to controls).[11,15] To that end, our results may have greater external validity, as the differences we observed in clinical and free-living gait parameters/physical activity between groups are less likely to be attributed to differences in demographic and anthropometric characteristics (no significant differences in demographic/anthropometric data between FAIS and controls), and more likely to be attributed to FAIS symptomology.

With respect to the pattern of physical activity accumulation (i.e., cadence bands), the control group spent approximately double the amount of time in slow and medium walking and triple amount of time in brisk walking intensities compared with FAIS group, with an observed large effect size between the groups (Table 3). However, the groups did not differ in the accumulation of time in the lowest intensity cadence bands (i.e., non-movement, incidental movement, sporadic movement, and ourposful movement; Table 3). Overall, this may suggest that both groups spent similar time at the lowest walking intensity levels but spent differing amounts of time at higher intensities and faster rates of walking. The comparison of time spent in these cadence bands suggests that either individuals with FAIS lacked the capacity to walk at higher rates of movement or chose to limit the amount of time spent at faster rate of movement. Clinicians working with individuals with FAIS may consider using wearable devices to evaluate walking behavior in real-world settings that would enable them to better understand the impact of FAIS, the effectiveness of rehabilitation or medical interventions, and/or to develop or target behavioral interventions specific to free-living walking behavior in this patient population.

Our study has several strengths and limitations that should be considered when evaluating our findings. It is the first study to comprehensively examine step-based metrics including peak cadence and time spent at various cadence bands during free-living conditions between individuals with FAIS and demographically-similar uninjured control participants. Although our sample size was small, our comparative study design allowed us to evaluate differences between groups with similar demographic and anthropometrics characteristics. For our study's limitations, we processed our FAIS accelerometry-data using cut points developed from healthy individuals, which might underestimate intensity of activity in those with FAIS due to natural differences in energetic cost of movement between those with FAIS and healthy controls. There is a need for further research to develop FAIS-specific accelerometry cut points in order to accurately define activity intensity in those with FAIS. Furthermore, we could not assume causality due to the cross-sectional design, and there may be bi-directional and reverse causality in play, meaning that we do not know if pain/functional limitations lead to lower activity/intensity or lower activity/intensity lead to pain/functional limitations. However, based on previous literature on patients with hip osteoarthritis, we know that hip-related pain and decreased function are often associated with low levels of activity.[48] Further, free-living physical activity, quantified herein using step-based metrics, may include non-step movement artifact. It is impossible to quantify the exact amount of measurement error related to this issue during free-living observation, however, we note that we collected and processed the accelerometer data per the manufacturer's recommendations and in general alignment with numerous other studies.[46] Minute level step data were computed and exported using ActiGraph's step algorithm, which has been validated both in laboratory controlled and free-living settings,[49-51] and is widely reported in the literature, including in national health surveillance such as the National Health and nutrition Examination Survey (NHANES; https://wwwn.cdc.gov/nchs/nhanes/2005-2006/PAXRAW_D.htm). In the current study, we did not collect or control for pain scores in those with FAIS. Thus, it is possible that higher or lower pain intensity at the time of testing could have influenced functional performance and walking-related measures (previous research has shown us that higher pain is often associated with lower activity[48]). Lastly, due to our small sample size, some of our group comparisons may have been underpowered to detect relevant differences; particularly in laboratory-measured cadence values, which did not statistically differ between groups but demonstrated small to moderate effect sizes.

Future studies are needed to comprehensively evaluate PA metrics that reflect the volume (steps/day) and peak effort/intensity (peak 1-minute and 30-minute cadence) of ambulatory activity, as well as time spent at various cadence bands that reflect a range of movement from non-movement to faster rates of locomotion in larger sample of individuals with FAIS. Additionally, there is a need for studies to develop and validate disease-specific cut-points for quantifying PA intensity in patients with FAIS. As opposed to just testing walking-related measures in clinical settings, clinicians should be encouraged to collect free-living physical activity data to examine effects of the clinical success of surgery alongside patient-reported outcomes in individuals with FAIS.

CONCLUSION

Individuals with FAIS took fewer daily steps, had a lower peak 1-minute and 30-minute walking cadence, and spent less time in faster rates of walking-related movement compared with uninjured control participants. Overall, clinical gait-related measures were generally similar between those with FAIS and uninjured controls when measured during laboratory testing, but those with FAIS demonstrated lower walking-related peak-effort/intensity during free-living measurement. Our findings support the use of wearable devices in patients with FAIS to examine how FAIS affects ambulation during free-living activity, and may be useful in identify deficits in gait parameters and step-based physical activity metrics that could be targeted through rehabilitation and/or behavioral interventions in this patient population.

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Figures Legends

Figure 1: Group Comparisons of Daily Steps (A), Peak 1-minute (B), and 30-minute Cadence (C)

Figure 2: Group Comparisons of Average Time Spent in Cadence Bands

Table 1: Characteristics of the Sample at the Testing Visit

	FAIS Group (n=25)	Control Group (n=14)	*p-value*^
Age*, years (range)	31.0 ± 9.2 (18.8-46.0)	28.1 ± 9.1 (20.4-50.4)	0.341
Sex, n (%)			
Female	15 (60%)	9 (64%)	0.792
Male	10 (40%)	5 (36%)	
Height*, cm	173.0 ± 13.1	170.2 ± 6.8	0.394
Weight*, kg	78.7 ± 21.7	76.1 ± 10.6	0.624
Body Mass Index*, kg/m^2	26.1 ± 4.7	26.3 ± 3.4	0.899
Accelerometer Wear Time* mean daily minutes	824.3 ± 71.5	836.7 ± 57.3	0.581
FAIS Subtype, n (%)			
Cam	13 (52%)	--	--
Pincer	4 (16%)		
Combined	8 (32%)		
Symptom Duration*, years	4.7 ± 7.1	--	--
IPAQ Scores:			
Average Time Spent in Vigorous Activity,	**38.8 ± 61.4**	**34.1 ± 25.0**	**0.747**

minutes			
Average Time Spent in Moderate Activity, minutes	**43.9 ± 85.0**	**16.4 ± 16.3**	**0.112**
Average Time Spent in Walking, minutes	**147.2 ± 172.0**	**67.9 ± 113.8**	**0.067**

Notes: *Data are reported as mean ± standard deviation (range) or n (%). ^P-values from independent two-samples t-tests for continuous data or Pearson chi-square tests for categorical data. FAIS, femoroacetabular impingement syndrome; kg, kilograms; cm, centimeters; m, meter. **IPAQ, international physical activity questionnaire.**

Table 2: Comparisons of Laboratory Gait Parameters During Self-Selected and Fast Walking Speeds

		FAIS Group (n=20)	Control Group (n=12)	*p-value*	*Effect Size (Cohen's d)*
Self-Selected speed	Cadence (steps/min)	113.6 ± 18.4	124.8 ± 15.5	0.077	0.7
	Velocity (m/s)	1.5 ± 0.5	1.6 ± 0.4	0.402	0.3
	Step Length (cm)	76.3 ± 11.9	76.9 ± 9.9	0.878	0.1
	Stride Length (cm)	152.8 ± 24.0	154.3 19.7	0.858	0.1
Fast-Walking Speed	Cadence (steps/min)	131.2 ± 17.5	138.8 ± 16.9	0.239	0.4
	Velocity (m/s)	1.9 ± 0.4	2.0 ± 0.41	0.625	0.2
	Step Length (cm)	86.5 ± 10.9	84.5 ± 10.2	0.594	0.2
	Stride Length (cm)	173.7 ± 21.9	169.4 ± 20.5	0.582	0.2

Notes: All data are reported as mean ± standard deviation. P-value was obtained using independent two samples t-tests. FAIS, femoroacetabular impingement syndrome; min; minute, cm; centimeter.

Table 3: Comparison of Step-Based Metrics and Time Spent within Different Cadence Bands between FAIS and Uninjured Controls

Outcome	**FAIS (n=25)**	**Uninjured Controls (n=14)**	***p-value***	***Effect Size (Cohen's d)***
Average wear valid days (days)	**6.2 ± 1.0**	**6.6 ± 0.7**	**0.170**	**0.4**
Daily Steps	5,346 ± 2,141	7,338 ± 2,787	0.030*	0.8
Peak 1-Minute Cadence (steps)	92.9 ± 23.9	119.6 ± 16.3	<0.001*	1.3
Peak 30-Minute Cadence (steps)	60.9 ± 27.1	86.8 ± 22.4	0.003*	1.0
Time Spent (mins/day) at non-movement (zero cadence/min)	1,079.0 ± 59.8	1.070.5 ± 97.3	0.769	0.1
Time Spent (mins/day) at incidental movement (1-19 steps/min)	273.7 ± 50.7	253.6 ± 74.4	0.378	0.3
Time Spent (mins/day) at sporadic movement (20-39 steps/min)	45.4 ± 19.9	46.0 ± 18.9	0.926	0.03
Time Spent (mins/day) at purposeful movement (40-59 steps/min)	15.6 ± 9.6	19.6 ± 6.5	0.134	0.5
Time Spent (mins/day) at slow walking (60-79 steps/min)	6.0 ± 3.6	10.3 ± 3.4	<0.001*	1.2
Time Spent (mins/day) at medium walking				

(80-99 steps/min)	4.5 ± 4.2	8.9 ± 4.4	0.005*	1.0
Time Spent (mins/day) at brisk/moderate waking (100-119 steps/min)	4.5 ± 6.2	12.2 ± 10.3	0.020*	0.9
Time Spent (mins/day) at faster walking (+120 steps/min)	4.0 ± 8.5	5.7 ± 5.9	0.461	0.2

Notes: Data are reported as mean ± standard deviation. P-values were obtained using independent two samples t-tests. * denotes significant difference between groups ($p < 0.05$). FAIS, femoroacetabular impingement syndrome; min; minute

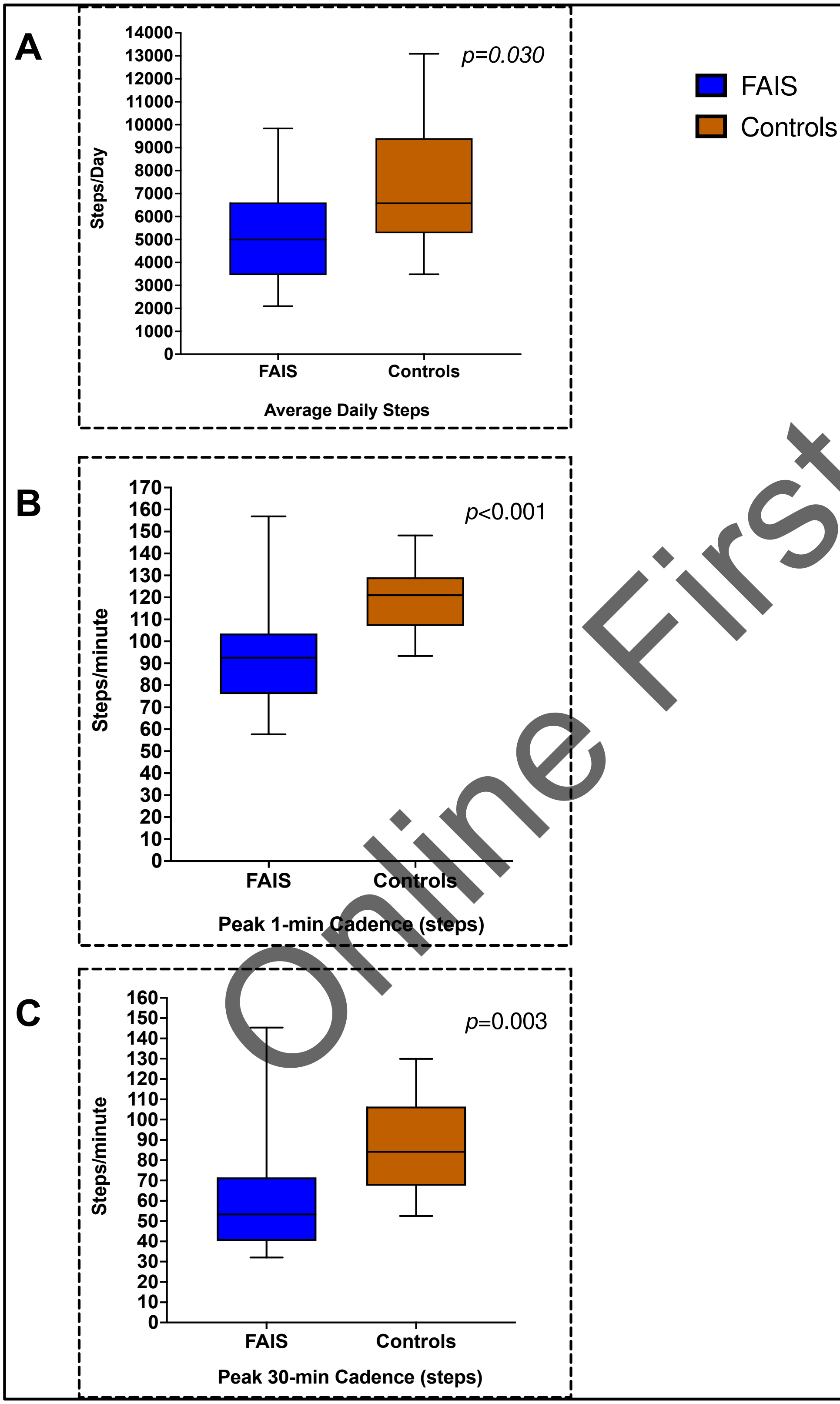

Figure 1: Group Comparisons of Daily Steps (A), Peak 1-minute (B), and 30-minute Cadence (C)

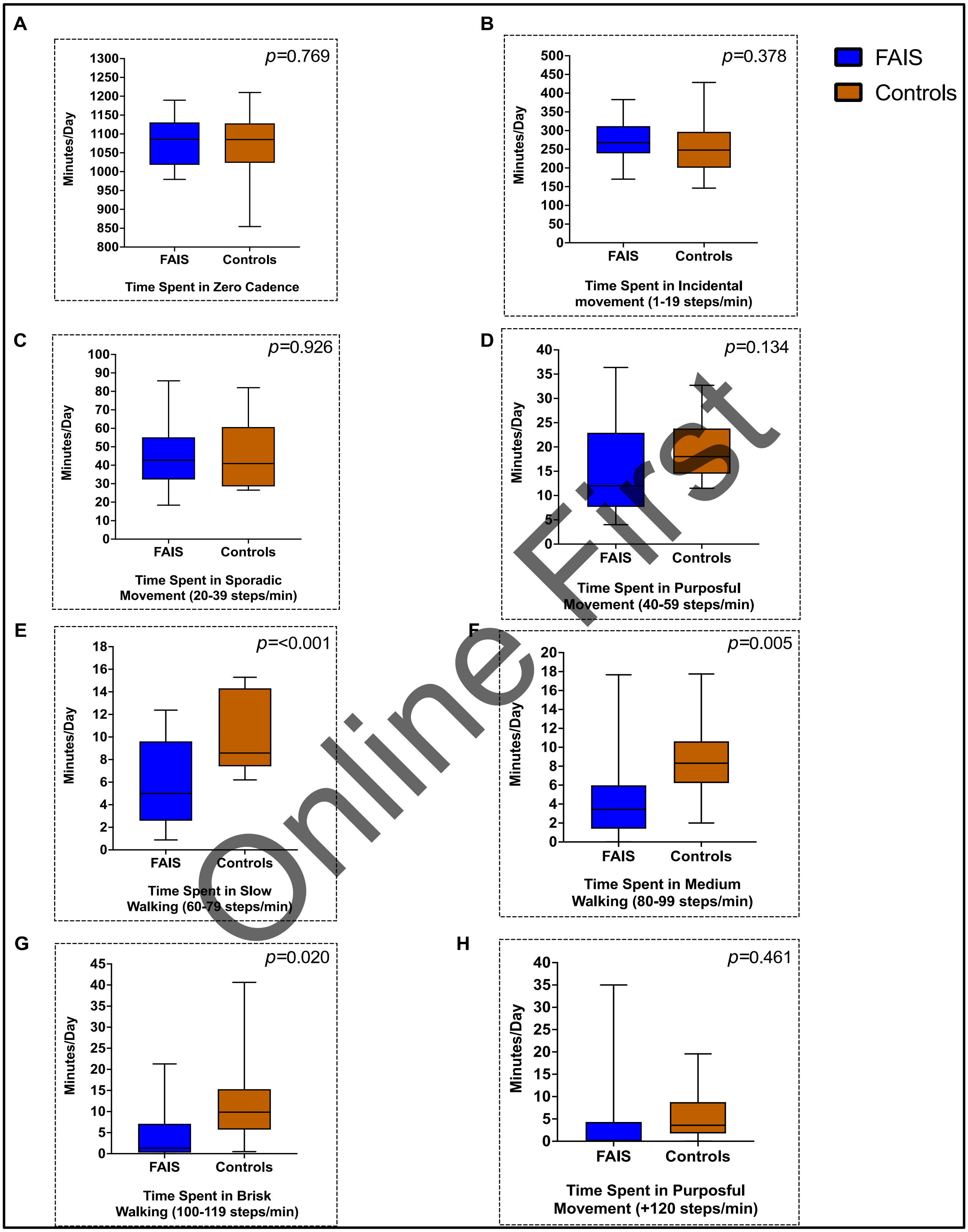

Figure 2: Group Comparisons of average time spent in Cadence Bands