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Research Article

Pain Assessed Using the Visual Analog Scale Differs between Initial Clinic Visit and the Day of Surgery in Orthopedic Patients and is Associated with Several Demographic Variables

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Abstract

Background: Pain assessment using the visual analog scale (VAS) is common during patient evaluation in orthopedic settings. However, several factors contribute to variability in patient pain scoring when only assessed in clinic. As a subjective psychological measure, we hypothesized that patient VAS scores would differ between the time of initial clinic visit (CV) and the day of surgery (DOS) and that the change in VAS scores (ΔVAS) would be associated with patient demographics, time of day and time between VAS recordings.

Methods: One-hundred-fourteen [m = 54, 42 ± 17yr | f = 60, 45 ± 16yr] orthopedic patients were recruited during their initial CV prior to surgery. Pain VAS was recorded using a handwritten mark on a 100-millimeter (mm) line representing a spectrum of no pain to worst pain at two time-points: CV and DOS. A ΔVAS of 14 mm was considered as a minimum clinically important difference (MCID) between measures. Demographics, time of day, time between CV and DOS measures and injury diagnoses were recorded. Student's t-test and analysis of covariance were used to detect differences in VAS between CV and DOS. Pearson correlation analysis was used to detect relationships between independent variables and ΔVAS. Type-I error set at $\alpha = 0.05$ for all analyses.

Results: VAS scores decreased on average when examining all patients (-4.86 ± 2.42 mm, $p < 0.05$) with 46% having a ΔVAS (increase or decrease) that exceeded the MCID (> 14 mm) and 24% with ΔVAS exceeding twice the MCID (> 28 mm). Patients with a body mass index ≥ 30 kg/m2 were found to have elevated VAS scores at DOS compared to < 30 kg/m2 ($p < 0.05$). Decreases in VAS were observed in patients < 35 years of age (-8.8 ± 3.7 mm), patients with knee (-15.5 ± 3.7 mm) rather than hip or upper body injuries, and patients who had morning CV appointments (-7.4 ± 3.2 mm) ($p < 0.05$). Age ($R = 0.19$) and initial VAS score during CV ($R = -0.39$) were found to be correlated with ΔVAS ($p < 0.05$).

Conclusion: Visual Analogue Scale scores vary considerably between CV and DOS in this patient population with the variance being partially attributable to several independent factors.

Level of Evidence: Level III, Retrospective.

Keywords: *Pain; Pain Management; Visual Analog Scale; Orthopedic Surgery*

Abbreviations

VAS: Visual Analog Scale; CV: Initial Pre-surgery Clinic Visit; DOS: Day of Surgery; NSAID: Nonsteroidal Anti-Inflammatory Drug; OTC: Over the Counter Pain Medication; BMI: Body Mass Index (kg/m^2)

Introduction

The visual analog scale (VAS) is a subjective measure of pain commonly collected in clinical settings [1]. Often considered a clinically important outcome measure in orthopedic settings, surgeons and physical therapists often utilize this scale during a patient's initial clinic

visit, prior to surgery, and post-surgery [1-4]. To complete a VAS recording, patients simply place a mark on a 100 millimeter (mm) line printed on a paper form that represents a spectrum listed from "no pain" (on the left) to "worst pain" (on the right) [5]. Electronic versions of the VAS have also been recently validated [6-8]. In addition to pain, the VAS has previously been used to evaluate severity of a variety of physiologic and psychological conditions related to mood or physical function [9].

Little is currently known about pain trajectories in the period between injury and surgery and what factors may play a role. In non-emergent situations, knowledge of temporal pain trends may improve the perioperative shared decision-making process. However, because VAS recording of pain is subjective and likely to be affected by a number of physiologic and psychological factors, pain measures among differing types of orthopedic patients (age, injury type, gender, etc.) may vary considerably. A variety of additional factors, including pain catastrophizing, self-efficacy, kinesiophobia and fear of re-injury, may also influence pain perception.

In light of previous literature and unpublished clinical observations, we hypothesized that pain VAS pain ratings would differ between the initial clinic visit (CV) and the day of surgery (DOS) in orthopedic patients. We also hypothesized that change in VAS scores between CV and DOS would be related to injury region, sex, body mass index (BMI), time of day for clinic appointment, initial pain level, pain medication, age and the time between CV and DOS.

Materials and Methods

This retrospective investigation was approved by the institutional review board for research involving human subjects. Data for one-hundred-fourteen patients seeking treatment for orthopedic injuries [m = 54, 42 ± 17yr, 29.31 ± 4.95 kg/m^2 | f = 60, 45 ± 16yr, 27.40 ± 5.49 kg/m^2] was examined from a single orthopedic outpatient clinic obtained on the day of initial CV with a treating surgeon (Listed in table 1 legend). Prior to meeting with their treating physician, patients were asked to complete a VAS recording of their level of injury-associated pain in a one-on-one setting. The same data was also collected for VAS pain recordings on the DOS during pre-operative assessment. Patients were excluded if they were unable to complete a pre-op measurement prior to surgery during DOS.

BMI	3 Group (BM = <25, 25 - 29, > 30 kg/m^2)	X 2 Time (CV and DOS)
Gender	2 Group (M/F)	
Injured Region	3 Group (Shoulder and Elbow, Hip, Knee)	
Age	3 Group (> 35yr, 35 - 54yr, > 55yr) x 2 (time)	
Time Between cVAS and dosVAS	3 Group (< 3 Weeks, 3 - 6 Weeks, > 6 Weeks)	
Time of Day of Clinic Visit	2 Group (Morning - AM, Afternoon - PM)	
Pain Medications	2 Group (Prescribed, Not Prescribed Between CV and DOS)	
*One-way comparisons also performed on change in VAS (AVAS) for the above variables as well.		

[Upper body]:	**[Knee]:**
Rotator cuff tear (n = 19)	Anterior cruciate ligament tear (n = 14)
Labral tear (n = 8), biceps tear (n = 8)	Meniscus tear (n = 29)
Acromioclavicular separation (n = 1)	Medial synovial plica (n = 4)
Shoulder stiffness (n = 1)	Tibial plateau fracture (n = 1)
Shoulder instability (n = 2)	Articular cartilage defect (n = 3)
AC joint arthritis (n = 5)	Synovitis (n = 2)
Biceps tenosynovitis (n = 7)	Chondromalacia (n = 3)
Rotator cuff impingement (n = 1)	Chondral defect (n = 1)
Supraspinatus tear (n = 2)	Meniscal deficiency (n = 1)
Clavicle fracture (n = 3)	Patellar instability (n = 2)
Degenerative joint disease (n = 2)	Posterior cruciate ligament rupture (n = 1)
Glenohumeral osteoarthritis (n = 1)	Corner rupture (n = 1)
Biceps tendon rupture (n = 3)	Nerve entrapment (n = 1)
Triceps tendon rupture (n = 1)	Arthrofibrosis (n = 1).
Ulnar nerve entrapment (n = 1)	
Biceps subluxation (n = 1)	
SLAP tear (n = 2)	
Ulnar collateral ligament tear (n = 1)	
[Hip]:	
Labral tear (n = 29),	
Impingement (n = 29)	
Micro instability (n = 28)	
Articular cartilage defect (n = 23)	
Synovitis (n = 7)	
Hamstring tear (n = 1)	
Sciatic nerve adhesion (n = 1)	
Minimus tear (n = 2)	
Iliotibial band syndrome (n = 5)	
Peritrochanteric pain syndrome (n = 1)	
Hip trochanteric bursitis (n = 3).	

Table 1: *Subgroup analysis and patient distribution.*

Statistical analysis for patient subgroup comparisons and patient injury descriptions.
Note: Several patients presented with multiple conditions within the same injured body segment.

Data for body mass index (BMI, kg/m^2), age, sex, prescribed [NSAIDs/Opioids] and over the counter (OTC) pain medications [taken between CV and DOS], time of day of CV (morning/afternoon), and injury diagnosis was collected from each patient's medical chart. Change in VAS was calculated between CV and DOS assessments. The length of time in days between measures was also recorded.

Sample size and power: Power analysis was performed utilizing data from a previous investigation performed in our laboratory [8]. For the primary outcome variable (VAS score) data were analyzed for a minimum detectable within-group difference of 14 mm on a 1 - 100 mm VAS scale between CV and DOS. This value is a previously established minimum clinically important difference (MCID) by Wolfe., *et al*. 2007 [10] and was used previously by our laboratory [6]. For a statistical power of 0.80 for subgroup comparisons, it was determined that a minimum within-group sample of 28 patients was required.

Statistical analysis

For analysis of the total subject population, a paired two-tailed Student's t-test was used to detect differences between CV and DOS VAS scores ($p < 0.05$). Next, to determine the effect of each of our sub-groups on patient reported pain between CV and DOS, the following generalized linear mixed-model analyses of covariance were used for the subgroups listed in table 1. For each sub-group comparison, all independent variables were included as covariates in the model. Following review of the Type-III tests of fixed effects, covariates not found to be significant in each model were excluded. In instances where group x time interactions were observed, a Tukey's post-hoc test was performed. Demographic variables within each subgroup were also compared using either a one-way analysis of variance, in independent samples t-test, or chi-square to for subgroup frequency comparisons. Pearson correlation analysis was used to determine whether or not a relationship was present between the following independent variables (BMI, age, time between measures, initial CV-VAS score) and the change in VAS score between CV and DOS. Significant correlations were defined as weak ($r < 0.4$), moderate ($r = 0.4 - 0.7$), and strong ($r > 0.7$). Type I error was set at $\alpha = 0.05$ for all analyses.

Results

Total subject population

An overall decrease in VAS score was observed between CV and DOS (-4.86 ± 2.42 mm, $p < 0.05$, Figure 1A). Forty-six percent of patients were found to have a change beyond 14 mm (increase or decrease) and 24% of patients were found to have a change in VAS score that exceeded twice the MCID (> 28 mm) (Figure 1B).

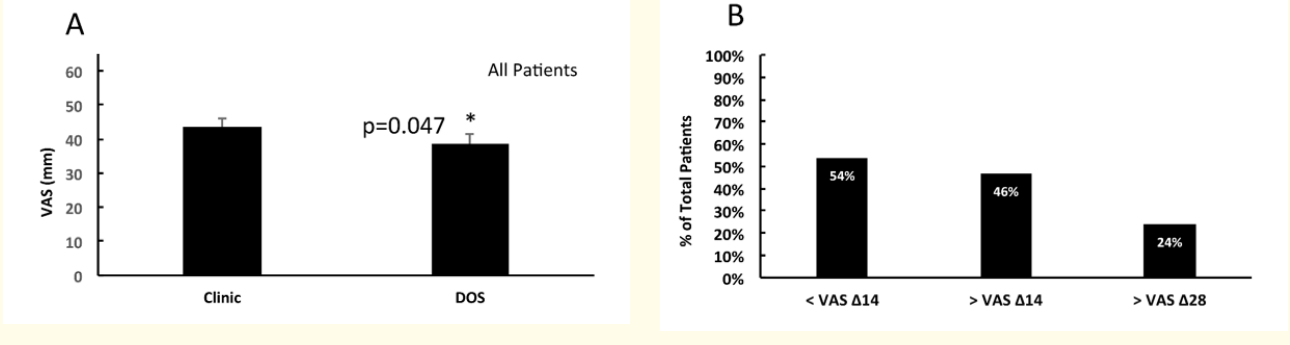

Figure 1: *Overall (all patients) VAS score recorded during initial clinic visit (clinic) and during pre-operative assessment on the day of surgery (DOS). Values are presented as means±SEM (1A) and as frequencies of patients whose change in pain between time points was below (<VAS Δ14), exceeded (>VAS Δ14), or more than doubled (>VAS Δ28) the minimum clinically important difference (MCID) of 14 millimeters (1B). *=significantly different from clinic visit VAS score (p<0.05).*

Subgroup comparisons

Descriptive statistics for all sub-groups are in table 2.

Gender	**n**	**Age (yr)**	**BMI (kg/m²)**	**% Shoulder and Elbow**	**% Hip**	**% Knee**	**Time (d) Between Clinic and DOS**	**% Morning Clinic Visit**	**% Afternoon Clinic Visit**
Male	54	42 ± 17	29.30 ± 5.00	25.44%	8.00%	14.00%	44 ± 44	21.05%	26.32%
Female	60	44 ± 16	27.50 ± 5.54	10.53%	19.30%	22.81%	44 ± 45	21.93%	30.70%
Time between clinic and DOS	**n**	**Age (yr)**	**BMI (kg/m²)**	**% Shoulder and Elbow**	**% Hip**	**% Knee**		**% Morning Clinic Visit**	**% Afternoon Clinic Visit**
< 3 Weeks	m = 18 | f = 16	43 ± 15	28.60 ± 5.17	12.28%	6.14%	11.40%		14.91%	14.91%
3 - 6 Weeks	m = 16 | f = 18	45 ± 18	28.50 ± 4.14	11.40%	7.02%	11.40%		10.53%	19.30%
> 6 Weeks	m = 20 | f = 26	42 ± 17	28.06 ± 5.82	12.28%	14.04%	14.04%		17.54%	22.81%
BMI	**n**	**Age (yr)**		**% Shoulder and Elbow**	**% Hip**	**% Knee**	**Time (d) Between Clinic and DOS**	**% Morning Clinic Visit**	**% Afternoon Clinic Visit**
< 25 kg/m²	m = 10 | f = 23	41 ± 18		6.14%	13.16%	9.65%	47 ± 39	10.53%	18.42%
25 - 30 kg/m²	m = 21 | f = 20	41 ± 16		14.04%	8.77%	13.16%	41 ± 43	20.18%	15.79%
30+ kg/m²	m = 23 | f = 17	48 ± 15		15.79%	5.26%	14.04%	46 ± 51	12.28%	22.81%
Age	**n**		**BMI (kg/m²)**	**% Shoulder and Elbow**	**% Hip**	**% Knee**	**Time (d) Between Clinic and DOS**	**% Morning Clinic Visit**	**% Afternoon Clinic Visit**
> 35 yr	m = 21 | f = 17		27.33 ± 4.68	7.89%	9.65%	15.79%	47 ± 44	14.91%	18.42%
35 - 54 yr	m = 20 | f = 24		29.11 ± 6.29	13.16%	9.65%	15.79%	47 ± 55	19.30%	19.30%
55+ yr	m = 13 | f = 19		28.53 ± 4.55	14.91%	7.89%	5.26%	39 ± 28	8.77%	19.30%
Injured body region	**n**	**Age (yr)**	**BMI (kg/m²)**	**% Shoulder and Elbow**	**% Hip**	**% Knee**	**Time (d) Between Clinic and DOS**	**% Morning Clinic Visit**	**% Afternoon Clinic Visit**
Shoulder and Elbow	m = 29 | f = 12	50 ± 17 a	29.72 ± 5.12				42 ± 44	15.79%	20.18%
Hip	m = 9 | f = 22	42 ± 17 ab	26.17 ± 5.56				59 ± 53	14.04%	13.16%
Knee	m = 16 | f = 26	38 ± 15 b	28.62 ± 4.97				44 ± 45	13.16%	23.68%
Clinic visit time of day	**n**	**Age (yr)**	**BMI (kg/m²)**	**% Shoulder and Elbow**	**% Hip**	**% Knee**	**Time (d) Between Clinic and DOS**		
Morning	m = 25 | f = 24	43 ± 16	28.61 ± 5.87	15.79%	14.04%	13.16%	44 ± 42		
Afternoon	m = 30 | f = 35	44 ± 17	28.12 ± 4.94	20.18%	13.16%	23.68%	45 ± 47		
Clinic visit time of day	**n**	**Age (yr)**	**BMI (kg/m²)**	**% Shoulder and Elbow**	**% Hip**	**% Knee**	**Time (d) Between Clinic and DOS**	**% Morning Clinic Visit**	**% Afternoon Clinic Visit**
No Meds	m = 37 | f = 37	43 ± 17	29.44 ± 4.99	65.00%	10.00%	25.00%	40 ± 45	55.00%	36.49
Meds	m = 17 | f = 23	44 ± 16	26.33 ± 5.42	15.00% #	62.50% #	22.50%	52 ± 44	36.49%	63.51%

Table 2: *Patient subgroup demographics.*

Subgroup comparisons are listed in the left column. Demographic comparisons for each subgroup are presented as means ± SD for patient age (years), body mass index (BMI, kg/m²), and time in days between initial clinic visit and day of surgery (DOS). Data are also presented as frequencies for percentage of patients being treated for upper body (shoulder and elbow), hip, or knee injuries as well as the percentage of patients whose initial clinic visits took place in the morning (before 1200h) or afternoon (after 1200h). For comparisons between 3 subgroups, differing letter subscripts indicate a pairwise difference between groups ($p < 0.05$). For comparisons between 2 subgroups, # = difference between groups ($p < 0.05$).

Age was found to differ between injured body region subgroups ($p < 0.05$). Group x time interactions were observed for patients grouped by BMI, age, injured body region, pain medication and time of CV (AM or PM, $p < 0.05$). No significant covariates were found to be present in any of the subgroup comparisons and were therefore excluded from final analysis. No effects of sex or time between CV and DOS measures were observed. Pairwise post-hoc analyses are presented in figure 2.

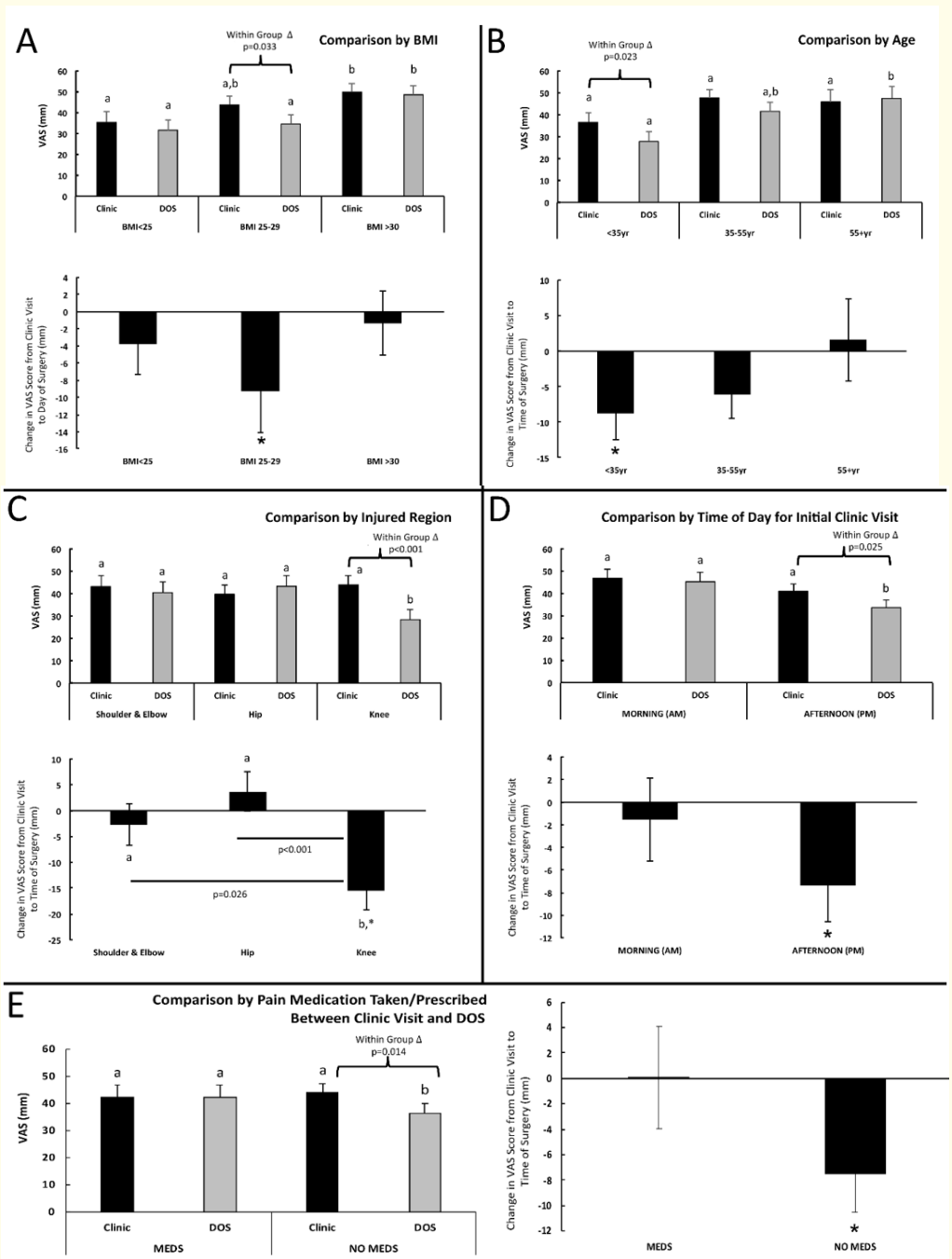

Figure 2: *Values are presented as means±SEM for VAS (top) and change in VAS (bottom) for each subgroup comparison of VAS scores recorded during initial clinic visit (clinic) and during pre-operative assessment on the day of surgery (DOS). Like letters = not significantly different at the same measurement time point (top) or across change between groups (bottom). { = significant difference between clinic and DOS VAS score (top). *=significant change from clinic VAS (bottom). (p<0.05).*

BMI (Figure 2A): CV-VAS scores were found to be higher in those with a BMI > 30 kg/m^2 (VAS: 49.83 ± 4.23 mm) compared to those with a BMI < 25 kg/m^2 (VAS: 35.34 ± 4.92) ($p < 0.05$). A decrease in VAS was observed for patients with BMI 25 - 29 kg/m^2 (VAS: -9.2 ± 4.88, $p < 0.05$) but not the BMI < 25 kg/m^2 or BMI > 30 kg/m^2 categories.

Age (Figure 2B): A decrease in VAS score between CV and DOS was observed for patients in the < 35yr category (VAS:-8.8 ± 3.7 mm, $p < 0.05$) but not the 35 - 55yr or 55+yr categories. VAS scores on the DOS were lower in the < 35 yr category compared to the 55+yr category ($p < 0.05$). A weak positive correlation ($R = 0.194$, $p < 0.05$) was observed between age and change in VAS between time points.

Injured body region (Figure 2C): A decrease in VAS score was observed for patients with knee injuries only (VAS: -15.5 ± 3.7 mm, $p < 0.05$) but not for the hip or shoulder and elbow regions. This resulted in VAS scores on the DOS to be lower in patients with knee injuries category compared to the other groups ($p < 0.05$).

Clinic visit time of day (Figure 2D): No differences were detected between groups at the time of CV although those who had their appointment in the afternoon (PM) tended to be lower on average. A decrease in VAS score was observed for patients who had their CV in the afternoon (VAS: -7.4 ± 3.2 mm, $p < 0.05$). This resulted in VAS scores on the DOS to be lower compared to those with a morning CV appointment ($p < 0.05$).

Pain medication (Figure 2E): A list of pain medications taken between CV and DOS are presented in table 3. Initial VAS scores during CV were observed to be similar between patients who did and did not take pain medication in the time between CV and DOS. However, only the those in the group that did not take medication were observed to have a significant change between timepoints (VAS: -7.5 ± 3.0mm, $p < 0.05$). Of note, we caution the reader that due to the required sample sizes for comparison, all medication types, dosages, and frequency of use were combined in the "Meds" group which may limit the interpretation of this result.

NO MEDS	**n = 74**
NSAIDS + OTC	**(n)**
Meloxicam	8
Ibuprofen	7
Aspirin	18
Celebrex	1
Naproxen	17
Celecoxib	3
Indomethacin	24
Nalfon	1
Tylenol	2
Aleve	2
Diclofenac	1
Opioids	**(n)**
Tylenol + Codeine	3
Norco	1
Tramadol	7
Morphine	1
Levorphanol	1
Vicodin	1

Table 3: *Pain medication use frequency between clinic visit and DOS.*

Initial clinic VAS: A moderate negative correlation ($r = -0.41$, $p < 0.05$) was observed between initial CV-VAS and change in VAS between CV and DOS measures indicating that change in VAS recorded pain is in part, correlated with patients' initial pain measures.

Discussion

In this study, patient VAS measures were observed to vary considerably between CV and DOS with a large portion (46%) of patients having changes in their scores (+or-) exceeding the MCID ($\Delta VAS > 14$ mm). We also observed that variance in VAS measures and change in VAS from CV to DOS is partially attributable to a number of independent factors. Although clinicians commonly incorporate pain metrics into surgical and rehabilitation decision making [11,12] along with more concrete diagnostic tools, these results indicate that a more refined means of pain tracking is needed.

Body mass index

Patients with a BMI ≥ 30 kg/m^2 tended to have higher VAS measures. This finding aligns with reporting that BMI-defined obesity (> 30 kg/m^2[13]) is associated with increased chronic and acute lower limb pain and inflammation [14-19]. The mechanical forces placed on joints are also greater in heavier individuals which may contribute to increased pain following injury [20].

Age

We observed that those over 55 years of age had significantly higher ratings of pain on the DOS compared to those under 35 and that change in pain between CV and DOS was correlated with age. Aging has long been associated with an increased frequency of conditions such as chronic inflammation, arthritis, longer healing timelines, and reductions in physical function [21-23]. Older adults have also been observed to have greater incidence of chronic pain and acute pain sensitivity [24,25]. In the present study, those in the < 35yr category had a significant reduction in VAS score between CV and DOS. While the cause of this finding remains uncertain, differences in pre-operative stress manifested in elevated cortisol and blood pressure levels have been reported among differing age groups (patient anxiety) [26]. Additionally, Tighe., *et al*. 2015 [27] observed that post-operative pain trajectories differ by age as younger patients (21 - 39yr) were found to have higher initial pain ratings compared to older adults (40+) and that older adults' pain resolved at a slower rate following surgery. Lastly, we cannot discount that the results observed here may also be related to patients' previous injury or clinic experiences [28].

Injured body region

Interestingly, CV-VAS measures did not differ between injury region groups. However, the mean change in VAS from CV to DOS was significant in patients with knee injuries compared to hip or shoulder and elbow. It is possible that region-specific inflammation, pain sensitivity, unloading following injury, and injury type may have played a role in these findings. This is in agreement with Defrin., *et al*. 2003/2006 [29,30] who observed body region dependent sensitivity to thermal and pressure based stimulus. Based on these findings and post-injury protocols related to immobilization and alterations in daily activities, we hypothesize that the potential for pain reduction is greater in the knee compared to the upper-body or hip. For example, reduced walking, bracing, elevation, icing, and utilization of either crutches or a wheel chair are all non-pharmacologic interventions that may greatly reduce activity and pain at the knee. In the case of the hip, activities such as sitting, standing, or repositioning may still elicit some degree of unavoidable pain [31,32]. The shoulder and elbow are not as commonly involved in daily ambulation tasks such as walking, sitting, or standing and it may be that pain management via immobilization, aside from icing or wearing a shoulder sling, does not contribute to any additional reductions in pain between CV and DOS. However, given the broad nature of our subcategories, future studies will be required to investigate specific injuries.

Time of day

Patients who arrived for CV in the afternoon were found to have a decrease in pain between CV and DOS. As patient surgeries took place in the morning hours for this population, these findings may be a result of the difference in time of day between CV compared to DOS. For example, joint-stiffness has previously been observed to differ between the morning and evening in healthy adults [33] and al-

though not directly associated with pain, inflammatory patterns have been reported to be linked to circadian rhythms [34]. Additionally, factors such as total time spent standing, walking, or other activities prior to CV compared to the DOS may have also differed between our comparison groups. Future investigations are needed to further elucidate the psychological and physiologic factors that affect pain with regards to time of day.

Pain medication

Expectedly, change in VAS measures differed between patients who received prescriptions for pain medication compared to those who did not. However, this change was in the form of a decrease in the "NO MEDS" rather than the "MEDS" group as was expected. One potential source of this finding may lie in subgroup differences for body region type (Table 2) with regards to the types of patients who were more likely to receive pain medication. Notably, the highest frequency of patients in the MEDS group were those undergoing treatment for hip injuries whereas shoulder/elbow injuries were most frequent in the NO MEDS group. For similar reasons related to regional body pain discussed earlier, we find it likely that perhaps immobilization strategies are likely more affective for mitigating pain in some body regions compared to others [29-32].

Sex

No effect of sex was observed in this study. This finding was contrary to our hypothesis and partially to previous literature regarding sex-based differences in pain sensitivity and reporting [35-38]. While women in our study exhibited higher VAS measures on average, the difference was not found to be statistically different at any time-point. Previous research indicates that women are more likely to have lower pain thresholds for a given stimuli, more likely to report severe or frequent pain compared to men [39] and that there are multiple biopsychosocial mechanisms such as sex hormones, endogenous opioid function, genetic factors, and pain coping mechanisms that may contribute to these differences [40]. However, the measures of this study were taken from just two specific time-points. Based on previous findings and our current results, we can only conclude that sex does not appear to play a significant role in VAS recorded pain at the specific time-points observed.

Length of time between measures

VAS measures were not affected by the length of time between CV and DOS. This was a surprising finding in that greater time between CV and DOS leaves a greater duration for pain reduction or worsening. Several factors also contribute whether or not immediate surgery may be needed for a given injury [41-43]. Therefore, the present result may be related to a number of confounding and inter-related factors. The question of whether or not length of time between measures effects ratings of patient pain should likely be further explored in the confines of specific injury types.

Limitations of the Study

This investigation is not without limitations. First, as VAS recorded pain is also related to psychological factors [44-46], we cannot discount that factors such as clinical setting may have affected VAS reporting. Second, as observed with our correlational analysis and by others [47], the magnitude of change in pain was found to be related to both age as well as initial CV pain measures. Therefore, although there are current standards for MCID thresholds for pain that were used in this study, our findings support previous observations [47] that MCID thresholds may vary depending on where an initial measurement is made on the scale. Regarding body mass, a conclusive limitation of this analysis is that we were unable to measure body composition (fat mass, lean mass, and bone mass), which is not considered when calculating BMI. We acknowledge that there are physiologic differences between individuals whose elevated BMI is related to elevated lean mass rather than fat mass [48]. Further study will be required to determine how body composition may influence pain in orthopedic patients. Next, we did not collect data on commute distance to the clinic and other daily living variables that likely influence VAS measures during CV and DOS. We also did not collect data on injury history or the timeline between when patients first became injured and their initial CV. We did not collect information on socioeconomic status shown to effect clinical reporting [49,50]. As this was a completely ran-

domized design, subgroups were not matched by gender or other demographic factors. Lastly, due to sample size and the retrospective nature of this study, we were unable to compare several potential variables related to pain medication use with regards to exact medications, dosages, dosing frequency, and time of last medication taken prior to surgery (all variables that may have effected VAS ratings). However, given that none of the independent variables examined in this investigation were observed to significantly influence any of the statistical modeling as co-variates, we are confident that the present findings indicate fairly independent contributions of each of the variables of interest to pain measures assessed during initial CV and DOS. Regardless, we acknowledge that prospective studies with VAS measures (in addition to other data) taken across several time-points with remains needed to fully explain some of the findings presented here. In a recent investigation from our laboratory, Delgado., *et al*. 2018 [8] observed that digital VAS scores recorded on a web-based platform can provide valid assessments of pain whereby measures can be logged to an online database. Therefore, more frequent pain tracking via electronic web-based platforms may provide considerable advantages with regards to surgical or therapeutic decision making and intervention strategies.

Conclusion

The primary conclusion from this investigation is that: 1) orthopedic patient pain measures are variable between the time that patients are seen in clinic for their first diagnostic visit and the day they arrive for surgery; 2) a high percentage of patients are likely to report changes in pain that exceed the MCID between these time-points; 3) These changes are partially dependent on factors such as patient age, injured region, time of day, initial pain measurement, medication, and BMI. While other factors likely also influence pain, these findings provide rational for further development of more effective and relevant methods for pain assessment over time rather than relying on single time-point measures taken in clinic. In a recent investigation from our laboratory, Delgado., *et al*. 2018 [8] observed that digital VAS scores recorded on a web-based platform can provide valid assessments of pain whereby measures can be logged to an online database. Therefore, more frequent pain tracking via electronic web-based platforms may provide considerable advantages with regards to surgical or therapeutic decision making and intervention strategies.

Conflict of Interest

No funding was received for the present work. The authors declare no potential conflicts of interest.

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