Gait quality assessed by trunk accelerometry after total knee arthroplasty and its association with patient related outcome measures

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Objectives

A proportion of patients continues to experience pain and reduced function after total knee arthroplasty (TKA), and patient reported outcome measures (PROMs) do not succeed in indicating why these patients still do not function satisfactorily. Data from inertial measurement units (IMU), e.g. accelerometers, have been successfully used to objectively evaluate gait quality. We determined which gait quality parameters change after TKA and whether these changes are associated with changes in PROMs scores. We hypothesized that trunk accelerometry would show improvements after TKA and would be moderately to strongly associated with the PROMs scores.

Methods

A prospective cohort study was performed in 2 large non-university teaching hospitals. Patients who underwent primary TKA were evaluated preoperatively and one year after surgery. A tri-axial accelerometer (sampling range -6g to +6g; sampling rate 100 Hz) was placed posteriorly at the level of the sacroiliacal joints. Patients were instructed to walk 2x50 meters at their own preferred walking speed. The following accelerometer gait characteristics were calculated: stride time variability (STV), low frequency percentage (LFP), stride regularity (SR), index of harmonicity (IOH), dominant frequency's amplitude (DFA) and harmonic ratio (HR). The changes between baseline and 1 year follow-up in gait characteristics and several PROMs (Knee Society Score (KSS), Oxford Knee Score (OKS), Knee Disability and Osteoarthritis Outcome Score (KOOS), EQ-5D, and a visual analogue scale (VAS) for quality of life (QoL)) were compared. Outcome parameters were analysed using non-parametric paired Wilcoxon signed-rank tests and correlations using Spearman's Rho.

Results

Sixty-five patients (mean age 65 years (range 41-75)) completed the entire protocol. Significant improvements one year after TKA were seen in 67% of gait quality parameters as well as in all the PROMs. Correlation tests showed that the change in OKS had the strongest significant associations with the changes in gait quality, even though the associations were mostly weak to moderate (Table 1). The changes in STV, SR and HR showed the overall highest correlation with the changes in PROMs. Changes in the VAS QoL and KOOS Symptoms score showed weak or no correlations with the changes in gait quality.

Correlation delta scores Spearman's rho (p-value)	VAS QoL	EQ-5D	KOOS					OKS
			Symptoms score	Pain score	ADL score	Sport & Rec score	QoL score	
Walking time meters/second	.153 (.252)	.251 (.057)	.147 (.270)	.222 (.097)	.330 (.012)	.175 (.229)	.275 (.037)	-.301 (.024)
Walking time 10 meters (seconds)	-.206 (.121)	-.232 (.080)	-.192 (.149)	-.298 (.024)	-.405 (.002)	-.128 (.381)	-.276 (.036)	.319 (.016)
Stride time variability (seconds)	.105 (.403)	-.184 (.143)	-.200 (.110)	-.329 (.009)	-.370 (.003)	-.161 (.239)	-.184 (.142)	.418 (.001)
Stride Regularity VT	.053 (.673)	.314 (.011)	.202 (.106)	.255 (.046)	.283 (.026)	.303 (.025)	.316 (.010)	-.411 (.001)
Stride Regularity ML	-.096 (.448)	.199 (.112)	.178 (.156)	.088 (.498)	.221 (.085)	.185 (.176)	.188 (.134)	-.350 (.005)
Stride Regularity AP	-.130 (.301)	-.066 (.599)	.149 (.237)	.061 (.640)	.027 (.834)	.046 (.738)	.046 (.716)	-.097 (.450)
Gait Symmetry (Harmonic Ratio) VT	-.100 (.426)	.193 (.124)	.184 (.143)	.214 (.095)	.257 (.044)	.129 (.349)	.184 (.141)	-.277 (.028)
Gait Symmetry (Harmonic Ratio) ML	.045 (.724)	.131 (.298)	.154 (.221)	-.022 (.866)	.096 (.459)	.076 (.580)	.176 (.161)	-.118 (.358)
Gait Symmetry (Harmonic Ratio) AP	-.112 (.376)	.146 (.244)	.055 (.666)	.050 (.700)	.139 (.283)	.052 (.707)	.197 (.115)	-.071 (.579)
Low Frequency percentage VT < 0.7 Hz	-.058 (.648)	-.279 (.025)	-.145 (.249)	-.146 (.257)	-.258 (.043)	-.186 (.173)	-.076 (.549)	.211 (.096)
Low Frequency percentage ML < 10 Hz	-.022 (.865)	-.002 (.987)	.007 (.956)	-.071 (.585)	-.113 (.384)	-.023 (.865)	.032 (.800)	.059 (.647)
Low Frequency percentage AP < 0.7 Hz	.092 (.013)	-.158 (.208)	-.306 (.013)	-.223 (.081)	-.269 (.035)	-.211 (.122)	-.252 (.043)	.341 (.006)
Gait Smoothness (Index of Harmonicity) VT	.039 (.759)	.239 (.055)	-.139 (.269)	.016 (.905)	.015 (.908)	.194 (.156)	-.002 (.986)	-.045 (.726)
Gait Smoothness (Index of Harmonicity) ML	-.126 (.319)	-.078 (.535)	-.259 (.037)	-.311 (.014)	-.295 (.020)	-.198 (.148)	-.198 (.113)	.243 (.055)
Gait Smoothness (Index of Harmonicity) AP	.049 (.701)	-.223 (.075)	-.098 (.439)	-.067 (.603)	-.169 (.189)	-.119 (.386)	-.128 (.309)	.168 (.189)
Dominant Frequency's Amplitude VT	.036 (.777)	.308 (.013)	-.023 (.853)	.144 (.264)	.140 (.277)	.315 (.019)	.168 (.182)	-.218 (.086)
Dominant Frequency's Amplitude ML	-.082 (.515)	.218 (.081)	.071 (.574)	.134 (.301)	.185 (.151)	.166 (.226)	.032 (.799)	-.137 (.285)
Dominant Frequency's Amplitude AP	-.114 (.364)	-.182 (.147)	-.068 (.592)	-.106 (.414)	-.190 (.138)	-.038 (.786)	-.041 (.743)	.133 (.297)

Not significant <,10 No association 0.10 weak association
0.30 moderate association 0.50 or higher strong association
VT=vertical; ML=medial-lateral; AP=anterior-posterior

Conclusions

Gait quality measured with IMU parameters from trunk accelerometry improved 1 year after TKA. Contrary to our hypothesis, there were only weak to moderate associations between most gait quality parameters (objective measurements) and the PROMs (subjective measurements). This indicates that PROMs are insufficient in evaluating functional outcome after TKA.

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