An Example of End-Digit Preference in Physiotherapy Practice

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ABSTRACT

Purpose: Standardizing and improving the validity of range of motion (ROM) measurements is of clinical relevance to physiotherapists. The purpose of this study was to assess whether end-digit preference exists in the measurement of knee ROM in people after knee replacement. **Method:** Following total knee replacement, 100 people underwent active-assisted knee ROM measurements using a goniometer calibrated in 1° increments. **Results:** The data showed strong end-digit preferences for 0s and 5s ($p < 0.001$). **Conclusions:** End-digit preference does exist in the measurement of knee ROM. This has the potential to influence both the validity of ROM measurements and clinical decisions.

Key Words: bias; measurement; reproducibility of results.

RÉSUMÉ

Objectif : Normaliser et améliorer la validité des mesures d'amplitude des mouvements (ADM) est particulièrement pertinent sur le plan clinique pour les physiothérapeutes. L'objectif de cette étude est d'évaluer si une préférence quant au dernier chiffre existe dans la mesure de l'ADM du genou chez les personnes qui ont subi un remplacement du genou. **Méthodologie :** À la suite d'un remplacement total du genou, 100 personnes ont subi des mesures actives assistées de l'ADM du genou à l'aide d'un goniomètre calibré selon des échelons de 1°. **Résultats :** Les données ont démontré une préférence marquée quant au dernier chiffre pour les 0 et les 5 ($p < 0,001$). **Conclusions :** Il existe effectivement une préférence quant au dernier chiffre dans la mesure de l'ADM du genou. Cette préférence pourrait avoir une influence sur la validité des mesures d'ADM et sur les décisions cliniques.

According to de Lusignan and colleagues, “End-digit preference describes the disproportionate selection of specific end-digits.”^{1(p.261)} (An *end-digit* is the terminal digit in a figure; for example, the numbers 13, 43, and 103 all have the end-digit 3.) The terminal digits most often implicated in end-digit preference are 0 and 5.^{2,3} Although measurement studies appear frequently in the physical therapy literature,^{4,5} reference to the phenomenon of end-digit preference is virtually absent. In contrast, end-digit preference is well documented in the medical literature, particularly as it applies to the measurement of blood pressure (BP).^{1–3,6–8} Paralleling the prominence of BP measurement in the day-to-day practice of physicians is the regular assessment of range of motion (ROM) by physiotherapists. Given that both BP and ROM assessments require clinicians to read and record analogue values, it seems reasonable to conjecture that end-digit preference may affect ROM measurements; however, our literature searches (PubMed, CINAHL, EMBASE) combining the terms “range of motion” and “end-digit” failed

to identify a single publication. Our purpose in this study was to assess whether evidence for end-digit preference exists in the measurement of knee ROM in patients following total knee replacement (TKR). Our null hypothesis was that the distribution of the end-digits 0 through 9 would be uniform (i.e., that end-digit preference would not be found).

METHODS

Study design

In our before–after study design, active-assisted knee flexion and extension ROM was assessed at admission to and discharge from a knee class for patients following TKR. Goniometers used in this study were calibrated in 1° increments (Rolyan 7514 and Jamar E-Z Read, Sammons Preston, Bolingbrook, IL).

Ethical approval was obtained from Sunnybrook Health Sciences Centre Research Ethics Board; all participants provided written informed consent.

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Table 1 End-Digit Frequencies for Knee Range of Motion Measurements

	End-digits									
	0	1	2	3	4	5	6	7	8	9
Current study flexion										
Baseline	36	0	5	5	2	32	2	4	10	4
Follow-up	42	6	5	7	1	23	7	2	6	1
Change	26	10	11	3	4	22	4	6	9	5
Current study extension										
Baseline	33	0	10	6	4	22	11	3	11	0
Follow-up	97	1	1	0	0	1	0	0	0	0
Change	31	0	10	6	4	24	11	2	11	1
Low (1976) ⁹										
Elbow	24	1	2	2	2	12	1	2	4	0
Wrist	20	0	3	1	1	18	3	3	1	0

Participants

Patients were eligible for the study if they had a unilateral TKR and were enrolled in a postoperative class focusing on individualized mobility, strengthening, and functional training. A total of 100 consecutive patients taking part in a multifaceted outcome measures study contributed data to our study.

Raters

Raters were three physiotherapists and one physiotherapy assistant. Physiotherapists varied in experience from 6 to 32 years; the physiotherapy assistant had 8 years of experience. All raters had performed goniometric measurements as part of their daily activities over their years of service and did not receive special training before this investigation began. No attempt was made to standardize the measurement protocol across raters.

Data analysis

We summarized patient and clinician characteristics using descriptive statistics. To test for end-digit preference, we applied a chi-square goodness-of-fit test. Based on our null hypothesis of a uniform distribution of end-digits and our sample size of 100, the expected frequency of each end-digit was 10. Analyses were performed for baseline, follow-up, and the difference between the two.

RESULTS

Of our 100 participants, 58 were male and 42 female; mean age was 68.7 (SD 8.2) years. The median (1st, 3rd quartiles) interval between TKR and admission to the postoperative knee class was 13 (11, 17) days. The median interval between admission and discharge from the postoperative knee class was 35 (33, 43) days. The median number of classes attended was 11 (10, 11). The mean baseline, follow-up, and change flexion ranges were 100.5° (SD 16.9°), 138.0° (SD 7.4°), and 37.5° (SD 14.8°) respectively; the mean baseline, follow-up, and change

extension ranges were 8.1° (SD 5.4°), 0.1° (SD 0.5°), and 8.0° (SD 5.3°) respectively.

Table 1 shows the end-digit frequencies for ROM measurements in our study. Our null hypothesis of uniform distributions for baseline flexion ($\chi^2_9 = 151.0$, $p < 0.0001$), follow-up ($\chi^2_9 = 149.4$, $p < 0.0001$), and change ($\chi^2_9 = 56.4$, $p < 0.0001$) end-digits was rejected. Our null hypothesis of uniform distributions for baseline extension ($\chi^2_9 = 97.6$, $p < 0.0001$), follow-up ($\chi^2_9 = 841.2$, $p < 0.0001$), and change ($\chi^2_9 = 93.6$, $p < 0.0001$) end-digits was also rejected. Our data show a strong preference for the end-digits 0 and 5.

DISCUSSION

Our findings were consistent with studies on end-digit preference in BP measurement,¹⁻³ in that raters in our study displayed a substantial preference for the end-digits 0 and 5. Although we were unable to find ROM studies addressing end-digit preference, raw data for elbow flexion and wrist extension ROM measurements were reported in a study by Low (1976), in which 50 experienced raters assessed the same person's elbow and wrist ROM.⁹ A summary of Low's results is shown in Table 1. Within this data set, end-digit distributions for the elbow and wrist measurements differ significantly from a uniform distribution (both $\chi^2_9 = 100.8$, $p < 0.0001$) and show a strong preference for the end-digits of 0 and 5.

End-digit preference has the potential to compromise the validity of clinical decisions. For example, a previous study estimated the minimal detectable change for knee flexion at 9°;⁵ for a patient whose true ROM is 108° at initial assessment and 117° at follow-up, a clinician subject to end-digit preference might record 110° and 115° and, as a result, conclude incorrectly that the patient has not improved.

Since the existence of end-digit preference has now been identified, the next step is to test strategies for minimizing its impact. Perhaps something as simple as

being aware of a propensity to prefer specific end-digits may be enough to modify clinician behaviour.

CONCLUSION

End-digit preference does exist in the measurement of knee ROM following TKR. Physiotherapists frequently record joint ROM and need to be aware of the phenomenon of end-digit preference. Because end-digit preference has the potential to influence the validity of ROM measurements and clinical decisions, we believe it is worthy of further investigation.

KEY MESSAGES

What is already known on this topic

Previous studies have examined the steps necessary to improve reliability and validity when standardizing ROM measurements, focusing on patient positioning, the environment, and the instrument.

What this study adds

Our results show that end-digit preference exists in the context of this study's characteristics (i.e., patient sample and setting) and is likely to exist in other contexts. Because physiotherapists frequently record joint ROM, they need to be aware of the phenomenon of end-digit preference.

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