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Intra-rater reliability of the knee arthrometer GNRB® for measuring knee anterior laxity in healthy, active subjects

Miha Magdič [a], Raja Gošnak Dahmane [b], Renata Vauhnik [a,c,*]

[a] Faculty of Health Sciences - Department of Physiotherapy, University of Ljubljana, Zdravstvena pot 5, Ljubljana, Slovenia
[b] Chair of Biomedicine, Faculty of Health Sciences, University of Ljubljana, Zdravstvena pot 5, Ljubljana, Slovenia
[c] Arthron, Institute for Joint and Sports Injuries, Ukmarjeva 2, Ljubljana, Slovenia

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ABSTRACT

Background: Arthrometers are used to assess knee anterior laxity and to evaluate the integrity of the anterior cruciate ligament. Assessment of knee anterior laxity is crucial part of the clinical examination. The aim of this study was to investigate the intra-rater reliability of the GNRB® in healthy subjects.
Methods: In the study participated 97 subjects and two measurements using a GNRB® arthrometer were performed. Males were tested two times one week a part. Females were tested two times within 24 h. Measurements were performed at the following forces 134 N, 134 N, 150 N, 200 N, and 200 N. To evaluate the reliability of GNRB® measurements an intraclass correlation coefficient was calculated.
Results: Intra-rater reliability of the GNRB® measurements is good for 134 N on the left knee (ICC = 0.848) and the right knee (ICC = 0.788) and for 200 N on the left knee (ICC = 0.805) and the right knee (ICC = 0.756).
Conclusion: The GNRB® knee arthrometer has good intra-reliability for measurements at the 134 N and 200 N forces. Reliability can be increased with the standardize position of the subject, the stabilization of the patella and standardize measurement protocol.

1. Introduction

Measurement with arthrometers is a method to evaluate integrity of anterior cruciate ligament (ACL). The method is an important component of the clinical examination of the knee joint.[1] Increased knee anterior laxity is risk factor for ACL injury[2,3] and traumatic knee injury.[4]

Arthrometers are devices that repeatedly apply force to the tibia and mechanically measure translation. The advantages are relative simplicity, rapid clinical application, greater objectivity compared to clinical examination, and lack of radiation exposure. The most commonly used devices in the literature are KT -1000 and KT -2000 (MEDmetric Corp, San Diego, CA, USA), Genourob (Genourob®, Laval, France), Rolimeter (Aircast Europa, Neubeuern, Germany), and Telos (Austin & Associates, Fallston, Maryland.[5]

The GNRB® robotic arthrometer (Genourob, Laval, France; GNRB®) was developed to improve the objectivity of knee anterior laxity measurement. Robert et al.[6] first described the GNRB® in 2009, and the device measures anterior tibial displacement at 20° of knee flexion. This mimics the position for the Lachman test while controlling pressure to stabilize the patella and measuring anterior tibial translation without activating the hamstring.[6]

Vauhnik et al.[7] reported that the intraclass correlation coefficient (ICC) of the GNRB® ranges from 0.338 to 0.786. Compared to Vauhnik et al.,[7] Mouarbes et al.[8] reported a lower ICC when measuring knee anterior laxity in healthy subjects (ICC = 0.414–0.486). Both have emphasized the need for precise determination of the standardized measurement protocol, as changes in knee position result in changes in tibial rotation and thus affect the measured knee anterior laxity.[6,9–11]

The aim of the study was to determine the intra-rater reliability of the GNRB® knee arthrometer for measuring knee anterior laxity in healthy, active subjects.

2. Material and methods

2.1. Participants

Ninety-seven participants (twenty-five men, sixty-two women; age: mean ± SD = 24.08 ± 9.08 years; body weight: mean ± SD = 69.12 ± 9.03 kg; height: mean ± SD = 174.36 ± 8.32 cm; body mass index: mean ± SD = 22.67 ± 1.87 kg/m^2) participated in the study. All participants

* Corresponding author. Zdravstvena pot 5, Ljubljana, 1000, Slovenia.
E-mail address: renata.vauhnik@zf.uni-lj.si (R. Vauhnik).

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participated in sports (19 football, 10 volleyball, 41 handball, 27 combinations of different activities such as running, gym, walking, and occasionally different sports). Inclusion criteria for the study were (1) no knee injury, (2) no tibia fracture, and (3) no poliomyelitis. Athletes were informed and invited to participate in the study with the assistance of medical staff and coaches. Recreational athletes were invited through social media and recreational training groups. All study participants have signed written informed consent. Minor participants were required to bring an informed consent form signed by their parents. Slovenian Medical Ethics Committee (0120–164/2020/10) approved the study.

2.2. Procedure and measurements

Knee anterior laxity was tested using the GNRB® knee arthrometer. Male participants attended testing sessions twice, one week apart. Female participants attended testing sessions within 24 h of each other. Because changes in sex hormone concentrations affect anterior knee laxity in females, we wanted to reduce the possibility of these changes influencing the measurement.[12]

Prior to measuring anterior knee laxity, participants' age, height, body mass, and sport type were recorded. Participants were positioned supine with their hands next to their bodies according to the device manufacturer's instructions.[6] The first leg tested (left or right) was determined by a lottery procedure. The tested leg was placed on a rigid adjustable support in a neutral position (with 0° tibial rotation) with the patella facing forward. The lower pole of the patella corresponded to the lower edge of the patellar support, and the joint line was palpated and marked. For both measurements, the force on the patella was symmetrical (≥60 N, with no more than 10 N difference between measurements). Three electrodes were used for feedback of hamstring activation during the test; one electrode was located on the lateral side of the tested knee, another on the medial proximal side of the hamstrings, and the third on the lateral proximal side of the hamstrings. First, an experimental measurement was performed to ensure the relaxation of the subject. Measurements were performed with the following forces on the tibia: 134 N, 134 N, 150 N, 200 N and 200 N. A displacement transducer (accuracy 0.1 mm) recorded the displacement of the anterior tibial tuberosity with respect to the femur. Anterior displacement data in millimeters were recorded on a laptop computer, on which a file of measurement results was created for each subject. Each measurement with explanation took between 20 and 30 min.

2.3. Data analysis

Intra-rater reliability was assessed by ICC (2.1). An ICC of <0.5 indicates poor agreement, an ICC of 0.5–0.75 moderate agreement, an ICC of 0.75–0.9 good agreement, and an ICC of >0.9 excellent agreement.[13] Bland & Altman plots and 95% limits of agreement were used to check the variance of the measurements.

3. Results

Participant characteristics and descriptive statistics for anterior knee laxity data are shown in Table 1.

The intra-rater reliability is shown in Table 2. The ICC values show good intra-rater reliability for the right leg at 134 N, the left leg at 134 N, the right leg at 200 N, and the left leg at 200 N. In Fig. 1 we see that the differences between the two measurements are very scattered (sometimes the first measurement is higher, sometimes the second measurement), the average is 0.

4. Discussion

The intra-rater reliability of GNRB® is good for measuring knee anterior laxity at forces of 134 N and 200 N. To our knowledge, our study is the first to describe the measurement protocol according to the device manufacturer's instructions, to maintain stabilization of the patella within 10 N between measurements and between left and right knees, and to use EMG electrodes for feedback of hamstring activation and to report ICC values for intra-rater reliability. We followed the device manufacturer's instructions for our measurements. In all 4 measurements performed (1st measurement on the right, 1st measurement on the left, 2nd measurement on the right, 2nd measurement on the left), the difference in stabilization of the patella was within 10 N. Using the EMG signal, we controlled the activation of the hamstrings, which is crucial because even a small contraction can reduce the anterior translation of the tibia.[14]

To our knowledge, Vauhnik et al.[7] were the first to report intra-rater reliability and ICC values using the GNRB® arthrometer on uninjured knees. Measurements of knee anterior laxity were performed in 13 healthy subjects in two ways. First, measurements were made without additional femoral stabilization at 134 N and 250 N, followed by measurements with additional femoral stabilization at the same forces. Intra-rater reliability was low to moderate, with ICC values ranging from 0.338 to 0.786. At a force of 134 N, a difference was observed between the left leg (ICC = 0.730) and the right leg (ICC = 0.450). For measurements with a force of 250 N, the intra-rater reliability is moderate (ICC = 0.5). They mention the possibility of the influence of a small sample as a reason for the difference in reliability between the left and right knee. Similar to them, Mouarbes et al.[8] also found poor intra-rater reliability with ICC values ranging from 0.414 to 0.486 at forces of 134 N and 200 N, respectively. Knee anterior laxity was measured in 30 healthy subjects. They reported that stabilization of the patella was maintained within 10 N between measurements, but they did not report the use of an EMG signal to provide feedback on hamstring activation. Our study shows higher ICC values compared to Vauhnik et al.[7] and Mouarbes et al.[8] The reason might be that the force to maintain patellar stabilization was well controlled and the hamstring activation was recorded. In addition, our study has the largest sample (N = 97) compared to Mouarbes et al.[8] (N = 30) and to Vauhnik et al.[7] (N = 13).

There may be several reasons for the greater variance between measurements. It should be noted that the GNRB® as robotic device is very sensitive to the subject's position.[7,8] The tibial displacement sensor

Table 1
Participant characteristics and anterior knee laxity at 134 N and 200 N (N = 97).

	Mean	SD	Range
Age (years)	24.08	9.01	16–53
Body height (cm)	174.36	8.32	154–195
Body mass (kg)	69.12	9.03	46–90
BMI (kg/m^2)	22.67	1.87	18.8–27.3
Knee anterior laxity (mm)			
Test 1 on right, 134 N	4.02	0.82	2.10–6.30
Test 1 on left, 134 N	4.19	0.85	1.60–7.60
Test 2 on right, 134 N	4.08	0.89	2.30–6.90
Test 2 on left, 134 N	4.19	0.85	1.50–6.40
Test 1 on right, 200 N	5.71	0.92	3.50–8.10
Test 1 on left, 200 N	6.02	0.96	2.90–9.60
Test 2 on right, 200 N	5.78	0.95	3.70–8.70
Test 2 on left, 200 N	6.01	0.95	2.60–8.70
Mean Test 1 and 2 on right, 200 N	5.74	0.87	4.05–8.25
Mean Test 1 and 2 on left, 200 N	6.01	0.91	2.75–9.05

BMI: body mass index, SD: standard deviation.

Table 2
Intra-rater reliability.

	ICC (2,1)	95% CI
Right leg, 134 N	0.788	0.716–0.844
Left leg, 134 N	0.848	0.794–0.889
Right leg, 200 N	0.756	0.674–0.819
Left leg, 200 N	0.805	0.736–0.865

ICC: intraclass correlation coefficients; CI: confidence interval.

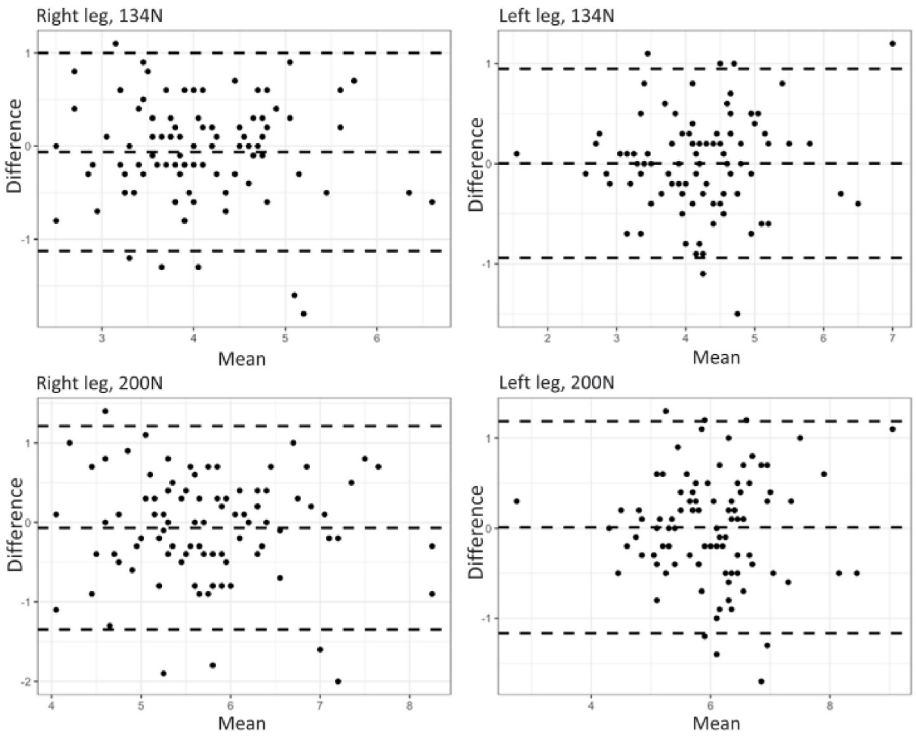

Fig. 1. Bland–Altman plot for difference in the Test 1 and Test 2 measures of knee anterior laxity.

is very susceptible to soft tissue motion errors and consequently tibial rotation errors that occur during the test. The sensor rests directly on the skin of tibial tubercle and thickness of the skin on the tibial tubercle may affect the measurement in overweight subjects.[8,15] Another reason could be the different positions of the device depending on the knee position between each measurement and the relaxation of the subject.[8] Changes in knee position resulted in changes in tibial rotation and thus influenced the measured anterior knee laxity.[9] Mouarbes et al.[8] and Alqahtani et al.[11] added that the reason for the differences in the measured knee anterior laxity could be the difficulty to maintain the stabilization of the patella during the measurements. The stabilization force is affected by the relaxation of the subject and the possibility of different use of fixation straps with the same stabilization force on the patella. Alqahtani et al.[11] reported statistically significant difference between the two measurements with different patellar pressure in healthy subjects. On the other hand, Bouguennec et al.[16] contradict these results. However, they used a pressure of less than 30 N on the patella in one of the groups, which was not in accordance with the device manufacturer's instructions. In our measurements, we followed the manufacturer's instructions: stabilization of the patella with $\geq$60 N with no more than 10 N difference between measurements. These arguments show the importance of the patella stabilization, standardized position of the subject and the standardize measurement protocol to improve the reliability of the measurements.

To our knowledge, our study is the first to describe the measurement protocol according to the device manufacturer's instructions, to maintain patellar stabilization within 10 N between measurements and between left and right knees, and to use EMG electrodes for feedback of hamstring activation and to report ICC values for intra-rater reliability.

Regardless of this study being the study with the largest sample, the studied sample included participants that are actively involved in sport activities and further reliability studies should evaluate reliability also among subjects who are not actively involved in sport.

5. Conclusions

The intra-rater reliability of the GNRB® knee arthrometer is good for the measurements with a force of 134 N and 200 N on the tibia. Standardization of subject position, patella stabilization, and measurement protocol is critical for reliable measurement.

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Institutional Ethical Committee Approval (for all human studies).

The study was approved by the Slovenian Medical Ethics Committee (0120–164/2020/10).

CRediT authorship contribution statement

Miha Magdič: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Raja Gošnak Dahmane:** Conceptualization, Methodology, Writing – original draft, Supervision, Writing – review & editing, Funding acquisition. **Renata Vauhnik:** Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing, Funding acquisition.

Declaration of competing interest

None.

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