



Keeogo™

TECHNICAL SUMMARY

Keeogo is a powered assistive walking device and is the first product to incorporate the Dermoskeleton technology developed by B-TEMIA Inc. Keeogo is a computer-controlled lower extremity motorized orthosis that has been used by individuals with medical conditions such as osteoarthritis of the knee and the hip, multiple sclerosis, Parkinson's disease, stroke, incomplete spinal cord injury, and other conditions that impact a person's mobility.

What is Keeogo?

Keeogo provides additional power to the knee joints in order to complete movements initiated by the user. Keeogo relies on artificial intelligence using kinetic and kinematic data from sensors located at the knee and hip joints. The system is powered by a lithium-ion battery.

This powered orthosis uses one motor at the knee, and three contact areas on each leg, that are adjustable for a wide range of morphologies.

Clinical Application of Keeogo

Keeogo can be used by patients with mobility impairments or endurance issues due to medical conditions, such as osteoarthritis of the knee, multiple sclerosis, Parkinson's disease, stroke, incomplete spinal cord injury, and others. Keeogo may improve walking function, independence and quality of life by reducing pain, compensatory movement patterns and fatigue.

Keeogo provides additional strength and stability to help complete a movement only when initiated by the user and is contraindicated for patients with complete spinal cord injury.

Keeogo helps patients with:

- Daily activities at home or in the community, with or without supervision
- Rehabilitation program with or without direct professional supervision

In addition to comprehensive clinician and user manuals, B-TEMIA has a team of clinical specialists who provide in-depth training sessions as well as ongoing clinical and technical support to ensure the greatest level of success for clinicians and patients.

Why should I work with Keeogo?

Since 2010, Keeogo has been involved in field testing, product evaluations, and clinical trials. Over 125 participants have tested the device in more than 20 studies. Highlights of findings are provided below.

Note: In these studies, K-SRD (Knee-Stress Release Device) is the generic designation quoted in the following papers, Keeogo (Keep On GOing) refers to the medical product.

1. Increased Walking Capacity

The use of Keeogo has been investigated across a variety of neurological conditions affecting mobility such as Multiple Sclerosis, Incomplete Spinal Cord Injury, and Stroke.

Participants performed mobility tests such as Timed Up-and-Go (TUG), Modified Timed Stair Test (MTST), and 6-Minute-Walk Test (6MWT), with and without Keeogo. Results showed improvement for each participant, in at least one activity [1]. One participant significantly increased their distance on a 6MWT, while

another switched from a step-by-step to a step-over-step strategy during stair climbing and completed the test faster. All participants mentioned that Keeogo™ helped in the “Up” part of the TUG.

An investigation was conducted across a wide range of neurological pathologies to identify which clinical markers could accurately predict improvement on a 6 Minute Walk Test (6MWT) and 25-Foot Walk Test (25FWT) with the use of Keeogo [2]. There was significant improvement in timed walking tests for those demonstrating an ideal level of baseline function in regards to balance, power and walking speed. It was concluded that Keeogo seemed to improve these outcome measures immediately in those who needed additional assistance when walking and had adequate strength to initiate movement patterns that the Keeogo artificial intelligence could recognize.

Another investigation was conducted on a patient recovering from an anterior cruciate ligament (ACL) reconstruction surgery (performed two weeks prior) [15]. This study showed improved confidence in walking (44%) while wearing Keeogo.

An investigation conducted by the Louisiana State University [19] on the K-SRD™ reported that users kneeling with the K-SRD™ experienced lower heart rate and lower rating of perceived effort, as soon as the first day of use. They were also able to double the number of repetitions of floor-to-waist lift tasks, and finally experienced a lower rating of perceived effort in climbing stairs.

2. Increased Balance and Stability

Balance impairments and increased falls risk are known to have a vast and meaningful impact on quality of life and independence in those living with mobility impairments.

Investigations on oscillation speed and displacement on a balance platform were performed on participants with Parkinson’s disease [6]. Results showed improvements for all conditions involving Keeogo, and 75% of the participants reduced their mean oscillation speed. A decrease in oscillation surface on the balance platform was demonstrated in all “with Keeogo” conditions, suggesting that the device has the potential to increase patients’ ability to maintain their balance.

3. Reduced Compensatory Movements

Populations with neurological and orthopedic impairments are prone to develop compensatory movement patterns, leading to long-term negative biomechanical issues.

Preliminary investigations in the Multiple Sclerosis population measured quality of gait with and without Keeogo [1]. The first 10 steps of the 6MWT were used as the reference to determine baseline hip trajectory. Each step thereafter was compared to this reference. Results showed significantly less deviation from baseline hip trajectories as the test went on when wearing Keeogo. This suggests that the device may help to maintain a better gait quality over the course of an extended period of walking.

4. Reduced Pain

Individuals living with knee osteoarthritis (OA) have a marked decreased quality of life, more disability [3] and struggle with persistent pain due to a lack of bracing options that truly eliminate symptoms of knee OA. [4].

Early studies suggested that Keeogo could be an effective solution by drastically reducing pain in three individuals with severe (K/L grade 4) knee OA population on their first use [5]. While performing tasks such as sit-to-stand, walking, stairs climbing, participants were asked to rate the pain on a 10-point visual-analogue scale (VAS). Results indicated significantly smaller (6-8 to 0-2) self-reported pain scores for all participants in all conditions. An analysis performed by the University of New Brunswick [16] suggested that a decreased knee moment and improved walking conditions could explain these results.

The ACL reconstruction study [15] also reported a 45% decrease in pain while performing physician recommended exercises and wearing Keeogo.

5. Improved Kinetics and Kinematics

A possible explanation for some of the aforementioned benefits of Keeogo may be attributed to an overall improvement in alignment, and reduction in moments in various planes on the human knee joint, and decreased maximum joint angles in higher intensity activities.

One example of this is the reduction in varus moment demonstrated in a study on healthy individuals over the course of walking and jogging tests (McGibbon [9] and Brandon [16]).

Another investigation on the swing phase while jumping was conducted with Keeogo and showed a reduction in joint angles and overall forces applied to the knee joint and reduced stress on the knee joint [7]. Results also showed the smallest knee displacement value was obtained with Keeogo™. Kinematic data validated these observations. Keeogo also increased medio-lateral stability [8] and provided better knee stabilization [9].

The investigation by the Louisiana State University [19] on the K-SRD observed that users wearing the device adopted better lifting techniques as early as the first day of use, suggesting a potential to decrease musculoskeletal injuries.

6. Results Applicable to Rehabilitation

Many of the study results are also applicable to rehabilitation use.

The study performed by Roy and Bédard [5] showed significant potential in increasing training volume without pain as a debilitating factor. This would be done by alleviating debilitating pain in patients living with arthritis, as a drastic decrease in self-reported pain levels was observed in all subjects across all conditions. Cantin [15] reported similar results in the ACL reconstruction study through a largely decreased pain level.

Cantin's [6] results showed promise in reducing overall fatigue in the Parkinson population by improving balance, reducing oscillation and improving posture. With

Keeogo, participants were able to perform activities that were unusual for them (running, lunging and kicking balls outside the functional tests).

Bouyer's [1] results showed promise in enabling more quality steps and volume, as the walking gait consistency was maintained for a longer period of time for Multiple Sclerosis patients. Participants performing standardized mobility tests experienced either the same performance with less effort or increased performance with the same effort. In a similar manner, Cantin [15] reported an increase in walking confidence.

Lamontagne [7] and Brandon [16] showed promise in relearning balance earlier in rehabilitation phase. Both studies reported an increased stability in the biomechanics of the knee joint. Tibial translation, frontal plane excursion and abduction moment were all decreased. Medio-lateral stability was increased. These factors could contribute to a reduction of risks of ACL tears, injuries of the medial and lateral ligaments, and a decrease in knee OA pain. .

St-Croix ([10] and [11]), Bedard [12], Tack [13], Vazquez [17] and Pacciolla [18] all suggest that the device may enable muscle strengthening earlier in a rehabilitation phase. Tests showed a mechanical advantage in squats and other deep-knee activities. Pacciolla [18] noted that one of the user's comments specifically targetted potential in rehabilitation and progressive return to work after an injury.

Conclusion

Keeogo has a high user acceptance, as evidenced by the early commercialization of the device in Canada. Additionally, in certain pilot studies, participants reported perceived improved performances and overall comfort of the device [12], including potential benefits to assist normal activities like walking, carrying, and lifting [10]. Benefits are expected both in daily use and rehabilitation settings.

Keeogo is commercially available for rental or purchase in Canada. It is not yet available in the United States. Keeogo is entirely developed and manufactured by:

B-TEMIA, Inc.
4780, St-Felix Street, Suite 105
St-Augustin-de-Desmaures (Québec)
G3A 2J9 Canada
1-866-443-1010
sales@keeogo.com | www.keeogo.com



Bibliography

- [1]. **Bouyer, Rahn, Routhier, McFadyen**; Pilot study on the effectiveness of B-TEMIA modified dermoskeletal technology on the mobility of persons suffering from Multiple Sclerosis, s.l. : CIRRIIS, 2013; Québec, QC, Canada. pp. 30.
- [2]. **Hick, McLeod**; Establishing a criterion for the Keeogo Dermoskeleton – a feasibility study, 2016; Hamilton, ON, Canada. pp. 4.
- [3]. **Alkan BM, Fidan F, Tosun A, Ardiçoqlu O.**; Quality of life and self-reported disability in patients with knee osteoarthritis. *Modern Rheumatology*, 2014; Volume 24, Issue 1. Ankara, Turkey. pp 6.
- [4]. **Duivenvoorden, Brouwer, van Raaij TM, Verhagen AP, Verhaar JAN, Bierma-Zeinstra SMA.** Braces and orthoses for treating osteoarthritis of the knee. *Cochrane Database of Systematic Reviews*, 2015, 3; Rotterdam, Netherlands. pp 82.
- [5]. **Roy, Bédard**; Pain levels with and without Keeego™; A pilot study with the knee OA population, 2014; Québec, QC, Canada. pp 1.
- [6]. **Cantin**; Rapport des tests effectués sur des patients atteints du Parkinson du 16-18 mai 2012, 2012; Québec, QC, Canada. pp 20.
- [7]. **Lamontagne, Varin, Anctil, Pageau, Bédard**; 3D kinematics and kinetics of drop jumps with the Knee Stress Release Device (K-SRD) Dermoskeleton™, 2012; Québec, QC, Canada. pp 2.
- [8]. **Anctil, Wonnacott, Lamontagne, Varin**; Evaluation of the Safety Aspects and Injury -Instrumented Mannequin Trials Reduction Capabilities of the K-SRD Under severe movement tasks, 2011; Ottawa, ON, Canada. pp 45.
- [9]. **McGibbon, Brookshaw, Smith, Muggah, Sexton**; Understanding the physiological and biomechanical effects of using the K-SRD Dermoskeleton™ during locomotion activities; Summary of preliminary outcomes. UNB, 2014; Fredericton, NB, Canada. pp 20.
- [10]. **Ste-Croix, Bray-Miners, Karthaus**; Evaluation of the K-SRD Beta 1.1 Prototype, 2013; Toronto, ON, Canada. pp. 66.
- [11]. **Ste-Croix, Bray Miners, Karthaus**; Uncontrolled Evaluation of the K-SRD Beta 1.1 prototype, 2013; Toronto, ON, Canada. p. 10.
- [12]. **B-TEMIA Team**; Initial Assessment & Demonstration of the Revision Military Prowler™, summary report, US Army NSRDEC, 2014; Boston, MA, USA. pp 19.
- [13]. **Ste-Croix, Mangan, Tack**; Evaluation of the B-TEMIA Knee Stress Release Device (K-SRD). s.l. : Human Systems, 2011; Toronto, ON, Canada. pp 69.
- [14]. **Serbu, Hrycyk**; Military Exoskeletons and the Revolution in Tactical Mobility, 2012; Kingston, ON, Canada. pp 77.
- [15]. **Cantin et al**; Pilot Study. A Trial Case: KEEOGO vs ACL Reconstruction Report, 2016; Québec, QC, Canada. pp 5.
- [16]. **Brandon et al**; Effects of an over-ground exoskeleton on external knee moments during stance phase of gait in healthy adults, 2016; Fredericton, NB, Canada. pp 44.
- [17]. **Vazquez**; K-SRD: Rapid Equipping Force (“REF”) Quick Look, 2016; Boston, MA, USA. pp 8.
- [18]. **Pacciolla et al**; BASI & B-TEMIA: Preliminary Evaluation, 2016; Montreal, QC, Canada. pp 23.
- [19]. **Hondzinski**; Pilot Report, 2016, Louisiana State University, Baton Rouge, LA, USA. pp 4.