DYNAMIC STABILITY ASSESSMENT FOR MONITORING RECOVERY FROM ACL RECONSTRUCTION A HANDBALL CASE STUDY

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Abstract:

Efficient postural balance/stability reduces the risk of injuries and contributes to motor performance in many sports disciplines. Handball is one of the most challenging sports for the knee joint. Continuous demands in strength and jumping alterations in movements are observed among athletes who have suffered anterior cruciate ligament (ACL) injury. In handball, as a typical "contact" team sport, these demands are enhanced with tactical and technical elements that make it more challenging in terms of dynamic stability. The scientific literature provides scarce information regarding the best clinical practices for rehabilitation programs or standardized functional and clinical evaluation criteria for resuming the sport after injury, different jumping performance tests have been widely employed to determine the readiness for sports participation after ACL reconstruction.

For this study, a descriptive case study was performed. This single case study involving a male elite handball player presents an example of how OptoJump Next Drift Protocol can be beneficial in monitoring the recovery process after ACL reconstruction. After the two ACL reconstructions, two Drift Protocol tests were conducted and a comparison between the two tests during the rehabilitation process indicates improvement in multiple measures. After the first test, according to the results, adjustments were made in order to balance the performance of both legs. At follow-up, 2 years after the second ACL reconstruction, the subject did not suffer any serious injuries in the meantime and had been pain-free since completing the rehabilitation program while continuing to participate in top-level handball.

Keywords:

Handball, ACL recovery, Dynamic stability, Drift protocol.

INTRODUCTION

Balance is an individual ability to maintain the line of gravity within the base of support. It is an essential ability for performing daily life motor functioning. Balance is often classified as static or dynamic, whereas static balance is seen as the ability to make adjustments to maintain posture while standing still, and dynamic balance is the ability to make necessary adjustments while the center of gravity and the base of support are in motion [1]. Efficient postural balance/stability reduces the risk of injuries and contributes to motor performance in many sports disciplines [2, 3]. Balance exercises are a key component of improvement in

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dynamic stability in many team sports such are basketball, handball, football, or rugby, where great demands on a player's ability to change direction when running were placed [4, 5]. Understanding of physical capacities that contribute to agility performance in team sports has shown two components: leg power [6, 7], and dynamic stability [8, 6]. In handball, as a typical "contact" team sport, these demands are enhanced with tactical and technical elements that make it more challenging in terms of dynamic stability. Furthermore, these two physical capacities influence agility, but they also interrelate with each other. Handball is one of the most challenging sports for the knee joint. Continuous demands in strength and jumping alterations in movements are observed among athletes who have suffered anterior cruciate ligament (ACL) injury. Although handball is a sport with a lot of "rough" contact between players from opposing teams, prospective studies aimed at investigating the incidence and risk factors of handball injuries are scarce. However, there is evidence that ACL injury is one of the most common and severe injuries among handball players [9]. Since standard static balance tests are not sensitive enough to detect the subtle changes in the proper functioning of postural control, we decided to use the dynamic test OptoJump Next System (Microgate, Italy) which has been proved to be valid and reliable [10]. OptoJump Next Drift Protocol is a test developed for verifying an athlete's dynamic stability. Unilateral functional jump tests, such as Drift Protocol, were recommended to examine deficits between extremities after ACL reconstruction [11. 12].

This study aimed to assess dynamic stability after two separate (one year between left and right leg injury) ACL-reconstructions of a rehabilitated elite handball athlete.

2. DRIFT PROTOCOL

The Drift Protocol is a test developed within OptoJump Next System for assessing an athlete's dynamic stability. An athlete needs to perform four jumping tests one after another on one leg measuring his/her displacement (drift) on the vertical and horizontal axis. The dynamic stability in the Drift protocol is expressed as displacement of the jumping point during the execution of 5 consecutive vertical jumps for each of the four tests, as seen in Figure 1.

The sequence of jumps in Drift Protocol is as follows:

- 5 jumps with RIGHT leg and feet PARALLEL to the OptoJump bars
- 5 jumps with LEFT leg and feet PARALLEL to the OptoJump bars
- 5 jumps with RIGHT leg and feet PERPENDICULAR to the OptoJump bars
- 5 jumps with LEFT leg and feet PERPENDICULAR to the OptoJump bars

The execution of 5 consecutive jumps in a given order requires adequate motor control and efficient postural stability. These factors are very important for jumping performance and they determine a good score in this test.

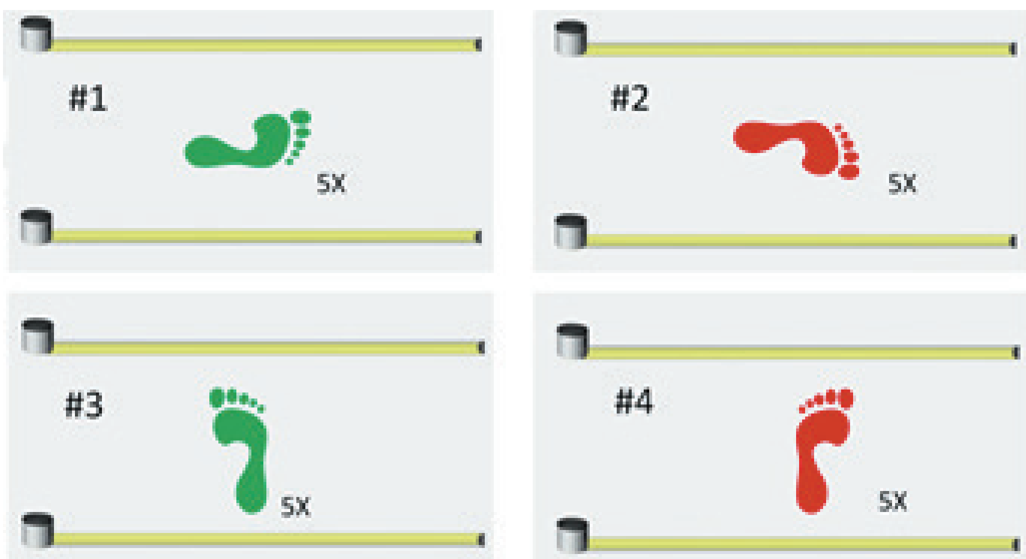

Figure 1 - Order of jumps in Drift Protocol

Drift Protocol

	L	R	Delta%
Average Height [cm]	12.1	10.9	9.4%
Average Power[W/Kg]	11.52	13.97	4.8%
Average Contact Time [s]	0.640	0.633	1.0%
Average Flight Time[s]	0.313	0.297	5.3%
Average LEFT/RIGHT Drift[cm]	4.7	6.1	-31.0%
Average FRONT/BACK Drift[cm]	3.4	-0.6	119.1%
Standard Dev LEFT/RIGHT Drift[cm]	28.6	9.4	67.1%
Standard Dev FRONT/BACK Drift[cm]	6.3	4.7	26.0%

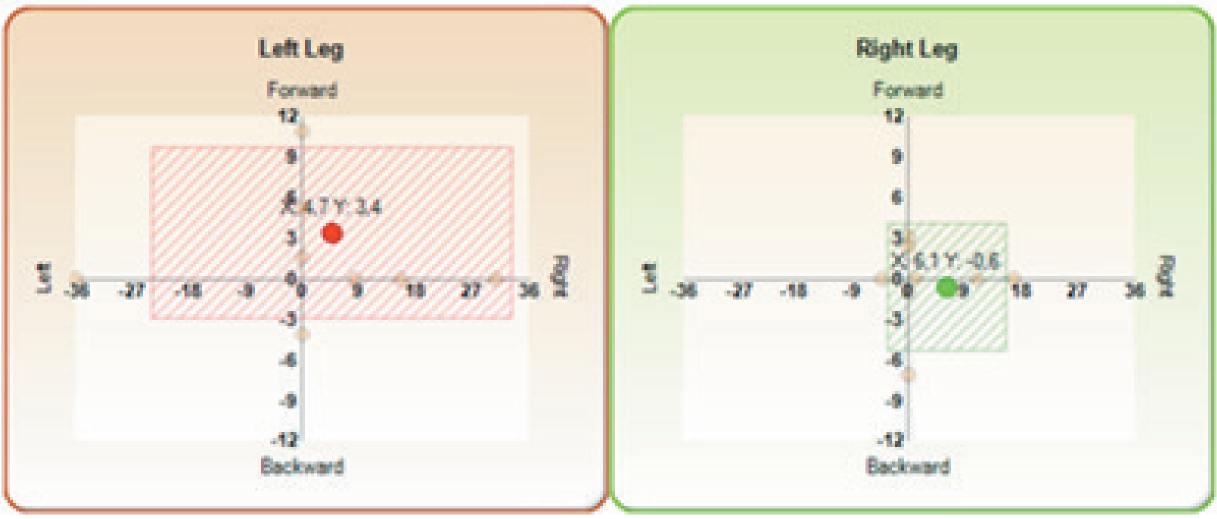

Figure 2 - Example of standard output for Drift Protocol with different covered areas for left and right leg [13].

Each jump is displayed as a yellow dot; the two large red and green dots (left and right) represent the athlete's tendency to move in a certain direction, whereas the dotted triangle indicates the 'stability area', as seen in Figure 2.

The larger the displayed area, the more has the athlete drifted (moved away from the point of origin) when landing, and consequently his/her dynamic stability can be seen as lower [13].

3. METHODS

For this study, a descriptive case study was performed. This single case study involving a male elite handball player presents an example of how OptoJump Next Drift Protocol can be beneficial in monitoring the recovery process after ACL reconstruction.

3.1. THE SUBJECT

The subject was a handball player of the National team of Serbia. The subject suffered two ACL injuries (ruptures), the first one occurred when he was 18 years old on the left knee, and the second one a year later on the right knee. The first ACL reconstruction took place in November 2016, and the return to play happened at the beginning of August 2017. The second injury occurred in the September of 2017 followed by another ACL reconstruction in the same month. The second return to full training and competition was at the beginning of August 2018. After both ACL reconstructions subject was put through a controlled rehabilitation exercise program for the knee joint stabilizing muscles and gradual strength training. It is worth noting that his dominant leg was left since leg dominance appears to play a role in the etiology of ACL injuries, i.e. female recreational soccer players and skiers are more likely to injure their non-dominant leg, whereas males tend to injure their dominant leg [14, 15, 16]. Although an ideal method to

Measure	Drift Protocol 1			Drift Protocol 2		
	Left	Right	Delta%	Left	Right	Delta%
Average height[cm]	16.2	26.0	-60.3%	19.5	27.5	-41.3%
Average power[W/Kg]	16.17	23.44	-44.9%	18.25	25.46	-39.5%
Average contact time[s]	0.450	0.416	7.5%	0.418	0.389	7.1%
Average flight time[s]	0.364	0.460	-26.7%	0.398	0.473	-19.0%
Average LEFT/RIGHT drift[cm]	1.0	-0.5	151.2%	0.7	4.0	-519.2%
Average FRONT/BACK drift[cm]	-1.6	-1.9	-23.8%	-1.4	-6.0	-319.3%
Standard deviation LEFT/RIGHT drift [cm]	8.9	25.0	-180.9%	5.0	22.0	-343.6%
Standard deviation FRONT/BACK drift [cm]	14.4	22.7	-58.0%	16.6	30.9	-86.3%
Area [cm^2]	511.2	2268.4	-343.8%	329.8	2725.7	-726.5%
Power Density [$W/Kg/dm^2$]	3.16	1.03	67.3%	5.53	0.93	83.1%

Table 1 – Drift protocol 1 and 2 parameters for the left knee rehabilitation monitoring

determine leg dominance is still lacking, we agreed to define his leg dominance as the leg he would use when required to push off the ground and then throw a ball, as previously described in handball [17]. The exercise program effects and rehabilitation process was monitored by Drift Protocol test on two occasions after both ACL reconstructions.

4. RECOVERY MONITORING

4.1. THE FIRST ACL RECONSTRUCTION RECOVERY MONITORING

After the first ACL reconstruction on the left knee, in November of 2016, the subject underwent a controlled rehabilitation exercise program for the knee joint stabilizing muscles and gradual strength training.

The first control/recovery monitoring by Drift Protocol testing was performed on 25 April 2017 and the second one on 17 June 2017. The results of the two tests are compared in Table 1.

As shown in Table 1, the standard output report of Drift Protocol consists of 10 measures to consider. A simple comparison between the two tests indicates improvement in several measures: average jump heights for both legs were higher on the second testing (left – from 16.2 to 19.5, right from 26.0 to 27.5 cm); lower difference between the jump heights for both legs (Delta 60.3% to 41.3%); average power output increased for both legs (left – from 16.17 to 18.25 W/Kg, right – 23.44 to 25.46 W/Kg); average contact time with surface decreased and average flight time increased for both legs.

However, some measures have shown a certain inconsistency. Namely, the average left drift has improved from 1.0 to 0.7 cm, but the average right drift deterred from -0.5 to 4.0. A similar pattern was noticed in average front/back drift with left leg improvement from -1.6 to -1.4 cm, whereas the right leg drifted from -1.9 to -6.0 cm. Quite the same scenario happened in a measure of 'stability area' which decreased for the left leg from 511.2 to 329.8 cm^2, while the right leg covered a larger area in the second test increased from 2268.4 to 2725.7 cm^2. These findings could be explained with a more focused rehabilitation exercise program for the knee joint stabilizing muscles and strength training of the left leg in comparison to the right leg. After these findings, the physiotherapist continued to supervise the subject's rehabilitation exercise program which was adjusted to a more balanced approach.

Measure	Drift Protocol 1			Drift Protocol 2		
	Left	Right	Delta%	Left	Right	Delta%
Average height[cm]	22.2	18.1	-20.3%	24.7	19.2	22.0%
Average power[W/Kg]	22.17	16.44	-29.7%	24.46	17.97	26.5%
Average contact time[s]	0.370	0.482	26.3%	0.356	0.442	-24.4%
Average flight time[s]	0.421	0.311	-28.7%	0.448	0.396	11.7%
Average LEFT/RIGHT drift[cm]	-1.5	4.6	101.2%	-1.8	3.1	271.2%
Average FRONT/BACK drift[cm]	-6.6	-10.9	-49.8%	-5.7	-10.3	-79.9%
Standard deviation LEFT/RIGHT drift [cm]	9.9	6.2	45.9%	11.7	5.3	54.5%
Standard deviation FRONT/BACK drift [cm]	7.4	27.7	-115.6%	6.0	25.4	-326.6%
Area [cm^2]	295.2	658.4	-76.8%	278.8	541.1	-94.1%
Power Density [$W/Kg/dm^2$]	7.76	2.63	98.3%	8.77	3.32	62.1%

Table 2 – Drift protocol 1 and 2 parameters for the right knee rehabilitation monitoring

4.2. THE SECOND ACL RECONSTRUCTION RECOVERY MONITORING

After the second ACL reconstruction on the right knee, in September of 2017, the subject was put through a rehabilitation process that included an exercise program for the knee joint stabilizing muscles and gradual strength training.

The first control/recovery monitoring by Drift Protocol testing was performed on the 9 of March 2018 and the second one on the 13 of April 2018. Before Drift Protocol testing began, the subject performed a standardized warm-up consisting of basic athletic drills and unilateral jumps that are used in the given testing protocol. The results of the two tests are presented in Table 2.

As detailed in Table 2, a comparison between the two tests during the rehabilitation process indicates improvement in multiple measures: average jump heights for both legs were higher on the second testing (left – from 22.2 to 24.7, right from 16.44 to 17.97 cm); average power output increased for both legs (left – from 22.17 to 24.46 W/Kg, right – 16.44 to 17.97 W/Kg); average contact time with surface decreased (left – from 0.370 to 0.356 s, right from 0.482 to 0.442 s), and average flight time increased for both legs (left – from 0.421 to 0.448 s, right from 0.311 to 0.396 s). Moderate improvements were registered in average front/back drift with left leg improvement from -6.6 to -5.7 cm, whereas the right leg drifted from -10.9 to -10.3 cm. A similar scenario was noticed in the measure of 'stability area' that decreased for both legs (left leg – from 295.2 to 278.8 cm^2, right leg from 658.4 to 541.1 cm^2).

Similar to the results from Table 1, with the left knee rehabilitation monitoring parameters, some measures have shown a certain inconsistency, but to a lesser content. First of all, there was a higher difference between the jump heights for both legs (Delta -20.3% to 22.0%) which can be explained by a fact that the subject has a dominant left leg. Another difference was noticed in one of the drift measures. Namely, the average left drift slightly decreased from -1.5 to -1.8 cm, whereas the right drift improved from 4.6 to 3.1 cm. These findings indicate that the second rehabilitation exercise program for the knee joint stabilizing muscles and strength training of the right leg was an improvement in comparison to the left leg rehabilitation process. Furthermore, at follow-up in October 2019, 2 years after the second ACL reconstruction, the subject did not suffer any serious injuries in the meantime and had been pain-free since completing the rehabilitation program while continuing to participate in top-level handball.

5. CONCLUSION

Although the scientific literature provides scarce information regarding the best clinical practices for rehabilitation programs or standardized functional and clinical evaluation criteria for resuming to the sport after injury, different jumping performance tests have been widely employed to determine the readiness for sports participation after ACL reconstruction [18]. OptoJump Next Drift Protocol, as a test developed for verifying an athlete's dynamic stability, has been proved to be valid and reliable [10]. As detailed above, the perceived benefits of using OptoJump Next Drift Protocol in monitoring the recovery process after ACL reconstruction, were evident. The medical team that was taking care of the subject's rehabilitation program, after the first ACL reconstruction conducted two Drift Protocol tests. After the first test, following the obtained results, adjustments were made in order to balance the performance of both legs. These findings prove to be useful in planning the second ACL rehabilitation program, where the subject achieved more balanced scores in the majority of Drift Protocol measures.

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7. REFERENCES

[1] T. A. McGuine, J. J. Greene, T. Best, and G. Leverson, “Balance As a Predictor of Ankle Injuries in High School Basketball Players,” *Clinical Journal of Sport Medicine*, vol. 10, no. 4, pp. 239–244, 2000.

[2] S.A Plowman and D.L. Smith, "*Exercise Physiology for Health, Fitness, and Performance*," Philadelphia: Wolters Kluwer, 2017.

[3] C. Hrysomallis, "Relationship between balance ability, training and sports injury risk." *Sports Medicine*, Vol.37, no. 6, pp. 547–556, 2007.

[4] J. Bloomfield, R. Polman, and P. O'Donoghue, "Physical demands of different positions in FA Premier League Soccer." *Journal of Sports Science and Medicine*, vol. 6, no. 1, pp. 63–70, 2007.

[5] A. Scanlan, B. Dascombe, and P. Reaburn, "A comparison of the activity demands of elite and sub-elite Australian men's basketball competition." *Journal of Sport Sciences,* vol. 24, no. 9, pp. 919-932, 2011.

[6] J.M. Sheppard, and W.B. Young, "Agility literature review: classifications, training and testing." *Journal of Sports Sciences*, vol. 24, no. 9, pp. 919-932, 2006.

[7] W. Young and D. Farrow, "A review of agility: practical applications for strength and conditioning." *Strength and Conditioning Journal*, vol. 28, no. 5, pp. 24-29, 2006.

[8] E. Bressel, J.C. Yonker, J. Kras, and E.M. Heath, "Comparison of static and dynamic balance in female collegiate soccer, basketball, and gymnastics athletes." *Journal of Athletic Training*, vol. 42, no. 1, 42-46, 2007.

[9] O.E. Olsen, G. Myklebust, L. Engebretsen, I. Holme, and R. Bahr, "Relationship between floor type and risk of ACL injury in team handball." *Scandinavian Journal of Medicine and Science in Sports*, vol. 469, no. 13, 299-304, 2003.

[10] K. J. Słomka, G. Sobota, T. Skowronek, M. Rzepko, W. Czarny, and G. Juras, “Evaluation of reliability and concurrent validity of two optoelectric systems used for recording maximum vertical jumping performance versus the gold standard,” *Acta of Bioengineering and Biomechanics*, vol. 19, no. 2, pp. 141–147, 2017.

[11] F.R. Noyes, S.D. Barber, and R.E. Mangine, "Abnormal lower limb symmetry determined by function hop tests after anterior cruciate ligament rupture." *American Journal of Sports Medicine*, vol. 19, pp. 513-518, 1991.

[12] G.D. Myer, L.C. Schmitt, J.L. Brent et al., "Utilization of modified NFL combine testing to identify functional deficits in athletes following ACL reconstruction." *Journal of Orthopaedic & Sports Physical Therapy*, vol.41, pp. 377-387, 2011.

[13] "Drift Protocol | Microgate," Microgate.it, 2021. https://medical.microgate.it/en/drift-protocol (accessed Mar. 28, 2022).

[14] G. Ruedl et al., "Leg Dominance Is a Risk Factor for Noncontact Anterior Cruciate Ligament Injuries in Female Recreational Skiers," *The American Journal of Sports Medicine*, vol. 40, no. 6, pp. 1269–1273, 2012.

[15] R. Brophy, H. J. Silvers, T. Gonzales, and B. R. Mandelbaum, "Gender influences: the role of leg dominance in ACL injury among soccer players," *British Journal of Sports Medicine*, vol. 44, no. 10, pp. 694–697, 2010.

[16] R. J. Negrete, E. A. Schick, and J. P. Cooper, "Lower-Limb dominance as a possible etiologic factor in noncontact anterior cruciate ligament tears," *Journal of Strength and Conditioning Research*, vol. 21, no. 1, pp. 270–273, 2007.

[17] J. Bencke, D. Curtis, C. Krogshede, L. K. Jensen, T. Bandholm, and M. K. Zebis, "Biomechanical evaluation of the side-cutting manoeuvre associated with ACL injury in young female handball players," *Knee Surgery, Sports Traumatology, Arthroscopy*, vol. 21, no. 8, pp. 1876–1881, 2012.

[18] I. Setuain et al., "Differential Effects of 2 Rehabilitation Programs Following Anterior Cruciate Ligament Reconstruction," *Journal of Sport Rehabilitation*, vol. 26, no. 6, pp. 544–555, 2017.