# 2.0 CONCEPTUAL CLARITY OF CONTACT

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In the previous paper in this series we have investigated the importance of why we need to measure contact in contact sports. It is now critical that we have conceptual clarity of what we mean by contact prior it's measurement. Incorrect, vague or inconsistent definitions and agreed contact banding thresholds create numerous problems for practitioners and researchers when measuring, reporting and understanding contact. Therefore, the aim of this paper is to establish clarity on contact terminology. It should be noted in addition to defining contact that other critically importance aspects are detailed in this paper, such as contact load within the training process puzzle and the PROTECHT contact intensity scale.

## CONTACT

Contact can be described as the change in momentum of the system as a result of an interaction with another system or inanimate object (including the ground). With the system being an athlete or part of an athlete i.e. a body part. This definition of contact encompasses the use of words such as collisions, impacts, strikes or any other word that would be associated with a change in momentum of the system as a result of an interaction with another system or inanimate object.

Change in momentum ($\Delta p$) is calculated through the mass ($m$) and the change in velocity ($\Delta v$) of the system.

$$\Delta p = m \cdot \Delta v$$

As the systems mass is conserved the resulting change in momentum is a result of a change in the systems velocity. In order to change a systems velocity an acceleration ($a$) of the system over a period time ($t$) must occur.

$$\Delta p = m \cdot a \cdot t$$

Therefore, if the systems mass is conserved contact can be defined as the change in acceleration to the system from the interaction of another system or inanimate object over a period of time. As mass times acceleration is force ($F$) this can also be written as.

$$\Delta p = F \cdot t$$

Contact can also be defined as a result of a force from the interaction of another system or inanimate object over a period of time (wiki).

## DAILY ACTIVITY V CONTACT SPORTING ACTIONS

Activities undertaken in daily activity such as running, walking, jogging, jumping and alternative forms of locomotion involve the application of a low level force applied to the system from an interaction with the ground [1]. Within the literature, this has been described and viewed as non-contact and is traditionally referred as low impact work and thus is not reported or included as part of the contact load undertaken by the athlete in training or competition [1–3]. It is important when measuring contact in sport, to only measure the load that occurs from the contact sporting actions and events and not those that occur from activities undertaken in daily activity. This ensures that the contact load reported is a true representation of the contact sporting actions and events an athlete undertakes.

## CONTACT LOAD AND THE TRAINING PROCESS PUZZLE

Having defined contact, we must understand how contact fits and interacts within the overall training process of contact sport (Figure 1) and the quantification of training loads imposed on athletes during or competition.

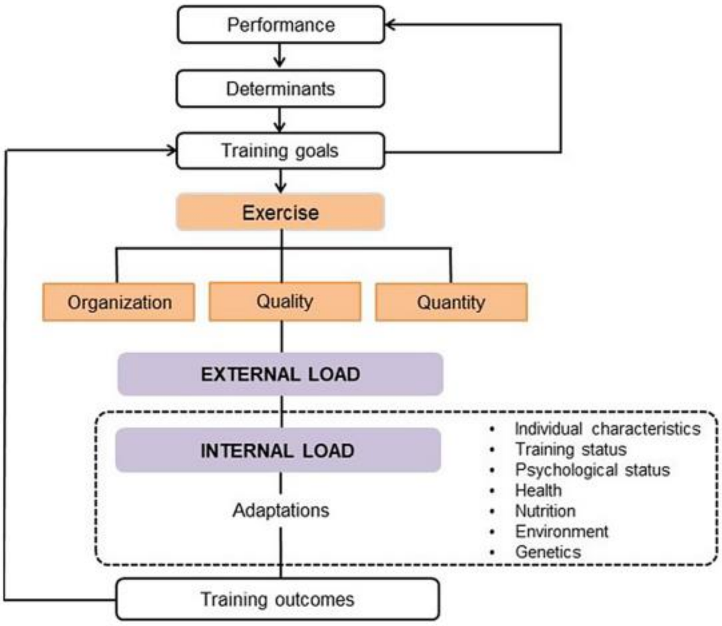


*Figure 1: Theoretical framework of the training process. Source:* [4].

Figure 1 outlines the theoretical framework of the training process, whereby targeted exercise induces a psychophysiological response and it is this response that provides stimulus for adaptation. The response to the stimulus and the stimulus itself is specific in nature, intensity and duration of the exercise task and the individual characteristics of the athlete i.e. training status, health, strength) [4,5].

Training load in the context of athletic training has been described as the input variable (external load) that is manipulated by coaches when prescribing training to elicit the desired training response (internal load) and subsequent outcome [4]. Training load can be quantified by a combination of internal and external loads, whereby the internal load represents the psycho-physiological response experienced by athletes whilst the external load broadly refers to the gross movement and actions of the athletes or the exercise performed [5,6]. The external load or 'dose' performed ultimately dictates the degree of internal biological strain (e.g. cardiovascular or metabolic) [5,6]. **Contact load** is an external load variable, defined as the quantification of the contact undertaken by the athlete within training, competition or phase. As a result, contact load is prescribed and manipulated by the coach to elicit the required training response and outcome of the athlete performing the contact exercise.

## CATEGORISING CONTACT LOAD VARIABLES

Contact load can be categorised by traditional training variables which is comprised of: type, intensity, volume, density and complexity [7]. Adaptation of the definition of these variables outlined in Periodisation theory and methodology of training [7] to contact these variables can be defined accordingly. **Contact type** is the activity of contact performed/undertaken by an athlete during the sport i.e. tackling, carrying, striking, hooking and jabbing. **Contact intensity** is the qualitative component of contact work an athlete performs per unit of time. With the work defined as the magnitude of acceleration undertaken based on our definition of contact. Therefore, the greater the magnitude of acceleration the athlete performs/undertakes per unit of time, a higher contact intensity will occur within an event, session or phase. **Contact volume** load is the total quantity of contact activity performed in training or competition. Therefore, contact volume can also be considered the summation of contact work performed during a session or phase. **Contact density** is defined as the frequency or distribution of contact training sessions or frequency at which an athlete performs a series of contact repetitions of work per unit of time. Complexity refers to the degree of sophistication and biomechanical difficult of a skill [7]. **Contact complexity** therefore refers to the difficulty of performing contact skills, with regard to cognitive and physiological demands. The performance of more complex skills in training can increase the intensity and impose a greater physiological stress [7]. For example, Eniseler [8] demonstrated that an athlete's internal response (heart rate, lactate accumulation) were higher when undertaking tactical training when compared with technical training in soccer athletes.

## THE IMPORTANCE OF INTENSITY CLASSIFICATION

Traditionally contact load has been reported by type and volume measured via video analysis, since no means of quantifying or categorizing the intensity of contact existed. Consequently, no intensity terminology was developed in order to explain contact intensity. As a result this has limited and prevented the universal acceptance and understanding of the measurement and implementation of contact load as an external load variable even with its importance previous outlined by practitioners and researchers [9]. In contrast, if we consider running load another external load variable which is widely used to measure and prescribe the locomotive demands of sport and training [9]. Running has an established means of measurement and recognized intensity banding classification as shown in Figure 2.

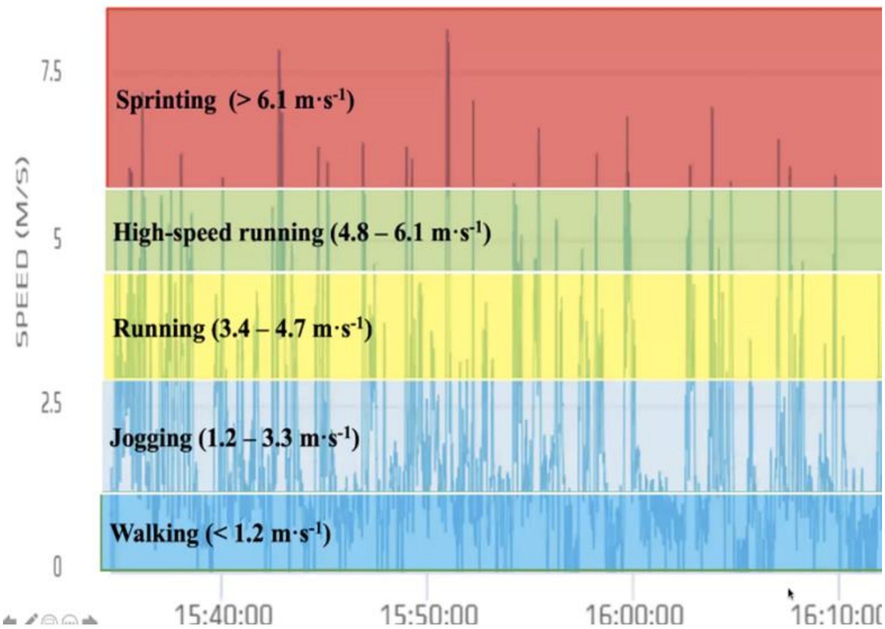


*Figure 2: Example of velocity intensity thresholds/bandings with associated running intensity terminology. Source: [10].*

Figure 2 highlights the use of running intensity classification such as: walking, jogging, running, high speed running, and sprinting which are determined by the magnitude of velocity undertaken by an athlete each run [10]. As the training or competition running demands can be broken down in this way. Training can be made more specific by the practitioner so that the athletes meet and train at the required competition demands, so that they are prepared to meet the demands of competition. In contrast, no such terminology or concept existed for contact, which subsequently meant that its use practically as a monitoring variable is limited, in addition to its understanding and acceptance. Therefore, in order to provide clarity within the measurement of contact load, the authors suggest the use of the **PROTECHT** contact intensity scale to define the intensity of contacts.

## THE PROTECHT CONTACT INTENSITY SCALE

The **PROTECHT** contact intensity scale describes the contact intensity based on the combined Z-score for peak linear and rotational acceleration values for each contact event using a normative data from each sport and population. A Z-score is a means at which data can be transformed and present different variables with different units in a standardised format. Used in combination with a benchmark, team, positional or individual data sets will provide greater information such as the difference and likelihood of normal and extreme events, enabling practitioners to make decisions for monitoring and training [11,12]. As a Z-score is used to measure each contact in terms of intensity this not only considers both acceleration components of the contact event but also makes it specific to each sport and population. The contact intensity banding levels were determined through standard deviation from the average as outlined in Table 1.

*Table 1: PROTECHT contact intensity scale*

| Contact Intensity Classification | Contact Intensity Banding Threshold (SD) |
|---|---|
| Minor | <-1 |
| Light | -1 |
| Moderate | 0-1 |
| Strong | 1-2 |
| Very Strong | 2-3 |
| Severe | 3-4 |
| Violent | 4-5 |
| Extreme | 5-6 |
| Extreme II | 6-7 |
| Extreme III | > 7 |

In the below example there are two athletes a boxer and a youth rugby athlete. Their corresponding competition averages and standard deviations are presented in Table 2. In this situation the boxer received a punch that was 35.2 *g* and 4300 *rad.s*$^{-2}$ and the youth rugby athlete that performed a tackle that was 22.1 *g* and 1020 *rad.s*$^{-2}$.

*Table 2: Example calculation of Z-score and corresponding classification of intensity of the contact event.*

| | Boxer | Youth Rugby athlete |
|---|---|---|
| Competition average Linear acceleration (*g*) | 37.5 ± 10.2 | 15.2 ± 5.7 |
| Competition average Rotational acceleration (*rad.s*$^{-2}$) | 3033 ± 501 | 1521 ± 323 |
| Linear impact received (*g*) | 35.2 | 22.1 |
| Rotational impact received (*rad.s*$^{-2}$) | 4300 | 1020 |
| Combined Z-score | 1.2 | -0.2 |
| PROTECHT contact intensity scale | **Strong** | **Light** |

*Mean ± standard deviation*

Using the above example and calculation their combined Z-score the boxer would have received a punch that had a Z-score of 1.2 which would identify that it was a "Strong" punch received by the boxer. Whereas, the youth rugby athlete who performed a tackle had a Z-score of -0.2 and which would identify that it was a "Light" tackle.

Applying the **PROTECHT** contact intensity scale to a larger data set which represents the competition demands for the sport and population, further information regarding the demands of sport and subsequent training implications can be derived. For example, Figure 3 presents a normative contact data set from professional rugby athletes collected over several competitions. The contact data was objectively measured through the **PROTECHT** system which uses smart sensors embedded in mouthguards to measure live acceleration contact data for each athlete on a team using the system simultaneously.

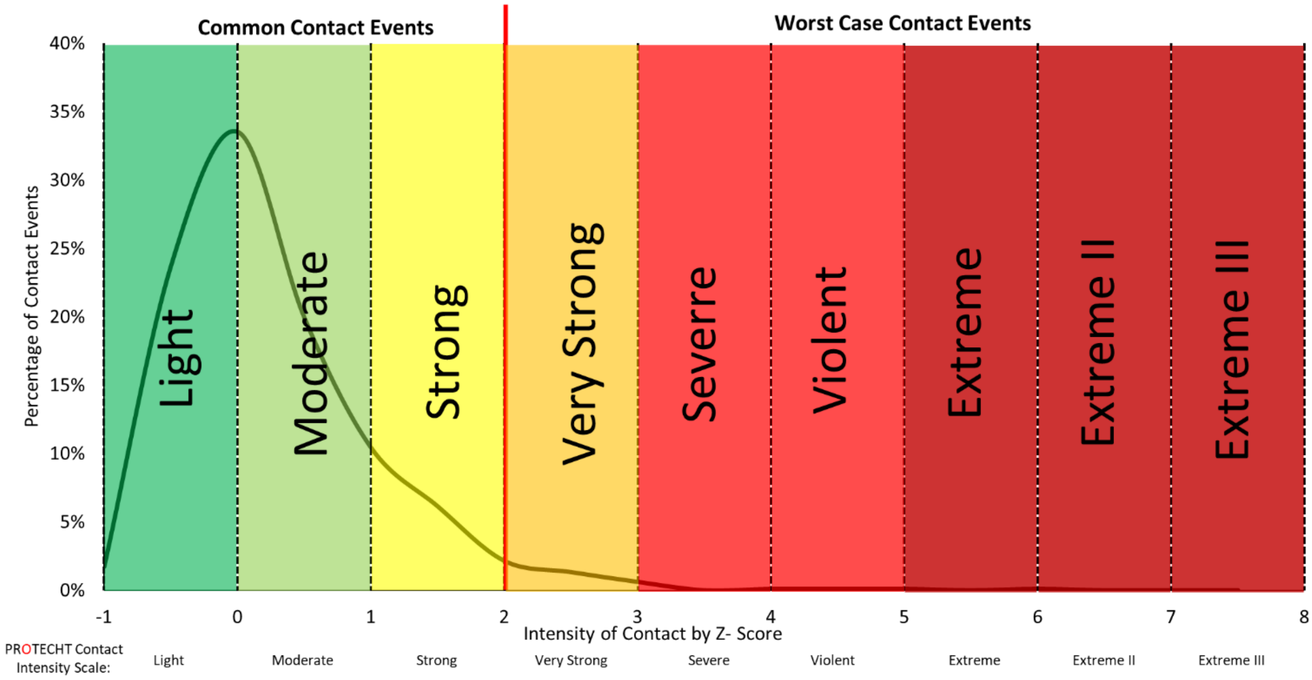


*Figure 3: Percentage of frequency distribution of contact events from professional rugby athletes using the* ***PROTECHT*** *contact intensity scale.*

Figure 3 shows the percentage of frequency distribution of rugby contact events from competition by intensity classified via the PROTECHT contact intensity scale. A number of interesting insights can be drawn from contact data represented in this way. Firstly, the data presented is not normally distributed and is positively skewed meaning that the contact data is a generalized extreme distribution and therefore extreme value statistics are required to analyse contact events [13,14]. The way in which the data is distributed demonstrates the varying nature observed in contact event, and further highlights its importance of needing to be measured above other external demands. For example, unlike running which is self regulatory from the athlete, contact is not only affected by the athlete but also external factors (opposition athletes). As the athlete could apply the same force, timing of force and technical position to a similar contact event but could attain a completely different outcome (magnitude and intensity of contact and success/failure or injury) due to changes in the external factor timing, force application, velocity, positioning and body mass.

Secondly much like the running demands rugby athletes are exposed to [15], the highest volume occurs at the lowest intensity and the highest intensity has the lowest volume. There are two distinct section shown in Figure 3, the common contact events (left side of red dashed line) and the worst case contact events (right side of the red dashed line). The most common contact events observed account for 97.5% of the contact events and therefore would need conditioning in order for an athlete to be able to tolerate the typical match demands they are exposed to. Presenting data in this way is extremely beneficial for training in area's such as return to play, prescription of training in terms of maintenance, tapering and periodization which are discussed in subsequent white papers. The worst case contact events, which represent contacts above the definition "Strong", account for less than 2.4% of all contact events measured from competition. Through video verification these contact events are a result of unavoidable and unexpected impacts which occur directly to the head from elbows, knees or shoulders from foul play, tackles, carries, ruck or the ground. Due to the extreme magnitudes an athlete is exposed to, the subsequent mechanism of contact and the percentage of these events occurring in competitions, practitioners should look to avoid these events in training and monitor the athlete closely during a competition if they occur. It emphasizes that it is essential to have a technology solution which captures contact load live and by intensity in order to review these events during competition and training. In addition, it would highlight the need for greater physical characteristics such as strength and power [16], the use of correct technique when undertaking contact events as this has shown to reduce the intensity of contact events [17] and enforcement of welfare rules to protect players from these situations, because if either are neglected it shows the extreme forces that an rugby athlete is exposed to.

Though the values used in this example is for professional rugby athletes, the principles would be the same for other sports and populations due to the way contact is calculated and classified by intensity. The work presented by SWA of the external load variable contact, has been conducted to increase the acceptance and understanding of contact for practitioners and researchers. As a greater understanding of the kinematics and subsequent response of contact in sport increases through the use of monitoring systems, this will eventually lead to an increase in performance and welfare of contact sport athletes

## SUMMARY

- There is no estblaished or clear terminology for contact which creates numerous problems for practitioners and researchers when measuring, reporting and understanding contact.
- We have defined contact as the change in momentum of the system as a result of an interaction with another system or inanimate object (including the ground). With the system being an athlete or part of an athlete i.e. a body part.
- When measuring contact in sport, it is important only to measure the load that occurs from the contact sporting actions and events and not those that occur from other activities.
- Contact load is an external load variable, defined as the quantification of the contact undertaken by the athlete within training, competition or phase.
- Contact load can be categorised by traditional training variables which is comprised of: type, intensity, volume, density and complexity
- SWA has developed the **PROTECHT** contact intensity scale to describe the contact intensity of each contact event.
- Applying the **PROTECHT** contact intensity scale to a larger data set which represents the competition demands for the sport and population, will provide further information regarding the demands of sport from which subsequent training implications can be derived.

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