CHAPTER 8

8.1 ANALYSIS AND INTERPRETATION

As mentioned in the previous chapter, four key components have been identified as indicators of the level of significance of dominant collisions when evaluating how tries are scored.

The following key performance measurements were evaluated and the relevant trend lines shown in order to indicate how each factor affected the level of success:

8.1.1 Average total number of collisions for a try to be scored

This statistic is determined during the notational analysis stage as the sum of the total number of ruck situations or phases forced, the number of forced missed tackles and the number of off-loads out of a tackle during play when a try is scored. This statistic shows the team’s ability to recycle possession effectively as well as the ability to “punch away” at the opposition’s defensive structure. With defensive systems being so effective, opportunities to score tries are scarce and the successful teams are better able to keep the ball for longer periods in so doing force mistakes from the opposition which can then be taken advantage of.

8.1.2 Average total number of forced missed tackles for a try to be scored

This indicates the relative strength and ability of the team when carrying the ball into a collision. The teams that are able to knock-over the opposition defenders with more regularity will in effect gain better yardage and “go-forward” possession. It also creates the situation where other defenders that form part of the system have to step in to cover for the player who missed the tackle; this creates holes in the defensive line which makes them more susceptible to having tries scored against them.

8.1.3 Ratio of dominant collisions versus passes executed when a try is scored

This statistic indicates the teams playing structure, i.e., does the team focus on carrying the ball forward, running at the opposition and being confrontational or do they tend to pass the ball around more in an effort to move the opposition around. A value below 1 (zero) indicates that the team passes more than what they force collisions when they score tries, and a value above 1 (zero) indicates that the team forces more collisions than what they pass the ball when they score a try.

8.1.4 Average positive velocity change of dominant collisions resulting in a try being scored

This is an indication of the relative difference between the ball carrier's momentum and the defender's momentum when they meet in a collision. The higher the value the greater the difference and the more ability the ball carrier has when the two players meet to "knock-over" the defender. This is a very good indicator of the team's strength into the collision and the force with which they are able to run into the opposition.

These four factors have been identified as the key factors required in order to prove the hypotheses that the teams that dominate the collision situation best are more likely to be successful in a rugby match and thus should win more matches than what they should lose. In order to evaluate the reliability and validity of these statistics the statistical significance has to be established.

8.2 The statistical significance of the data

Inductive reasoning moves from specific facts to general, but tentative conclusions. We can never be absolutely sure that inductive conclusions are flawless. With the aid of probability estimates, we can qualify our results and state the degree of confidence we have in them. Statistical inference is an application of inductive reasoning. It allows us to reason from evidence found in the sample to conclusions we wish to make about the population. The process of getting probability estimates and calculating the degree of confidence we have in our data is called hypotheses testing. The purpose of hypotheses testing is to determine the accuracy of the hypotheses and the validity of the statistics in order to prove or disprove the hypotheses. The accuracy of the hypotheses is evaluated by determining the statistical likelihood that the data reveals true differences – and that there is not random sample error. We evaluate the importance of a statistical significance difference by weighing the practical significance of any change that is measured (Cooper & Emory, 1995; Cooper & Schindler, 2001).

The Null hypothesis is used for testing. It is a statement that there is no difference between the parameter and the statistics being compared to it. In this case a one-tailed approach to the Null hypothesis will be used (Cooper & Emory, 1995; Cooper & Schindler, 2001).

8.3 The statistical testing procedure

Testing for statistical significance follows a relatively well-defined pattern; the six-stage sequence is as follows:

1. state the null hypothesis;
2. choose the statistical test;
3. select the desired level of significance;
4. compute the calculated difference value;
5. obtain the critical test value; and
6. interpretation of the test (Cooper & Emory, 1995; Cooper & Schindler, 2001).

8.4 The tests of significance

There are two general classes of significance tests: parametric and nonparametric. Parametric tests are more powerful because their data are derived from interval and ratio measurements.

Nonparametric tests are used to test the hypotheses with nominal and ordinal data. In this study parametric tests will be used, as the data is interval and ratio data. Parametric techniques are the tests of choice if their assumptions are met. Assumptions for parametric tests include the following:

- The observations must be independent – that is, the selection of any one case should not affect the chances for any other case to be included in the sample;
- The observations should be drawn from normally distributed populations;
- These populations should have equal variances; and
- The measurement scales should be at least interval so that arithmetic operations can be used on them (Cooper & Emory, 1995; Cooper & Schindler, 2001).

8.5 The selection of a statistical test

In attempting to choose a particular significance test, the following three questions should be asked:

- Does the test involve one sample, two samples or *k* samples?
- If two samples or *k* samples are involved, are the individual cases independent or related?
- Is the scale of measurement nominal, ordinal, interval or ratio?

For this research the *k*-sample case is used. The samples are related and the data used is interval and ratio. Therefore the test that will be used would be the repeated measures ANOVA test. See Table 8.1 below detailing the criteria when deciding on a relevant test to use as discussed above.

Table 8.1: Criteria for relevant hypotheses testing

Measurement Level	One-Sample Case	Two-Sample Case Related Samples	Two-Sample Case Independent Samples	*k*-Sample Case Related Samples	*k*-Sample Case Independent Samples
Nominal	Binomial X-Square One Sample	McNemar	Fisher exact X-Square Two Sample	Cochran Q	X-Square for k Samples
Ordinal	Kolmogorov-Smirnov one - Sample test Runs Test	Sign Test Wilcoxon matched Pairs.	Median test Mann-Whitney U Kolmogorov-Smirnov Wald - Wolfowitz	Friedman two-way ANOVA	Median extension Kruskal-Wallis One-Way ANOVA
Interval / Ratio	t - test Z - test	t - test for paired samples	t - test Z - test	**Repeated measures ANOVA**	One-Way ANOVA n-way ANOVA

(Adapted from: Cooper & Schindler, 2001)

8.6 *k* - Sample related case for interval / ratio data

The repeated-measures ANOVA is a special form of n-way analysis of variance and will be used in this case.

During the following testing procedure, the following is stated:

1. Null hypotheses

    (1) Key Measurement: Ho: $\mu_{K1} = \mu_{K2} = \mu_{K3} = \mu_{K4}$

    (2) Year Rating: Ho: $\mu_{Y1} = \mu_{Y2} = \mu_{Y3}$

    (3) Year Rating × Key Measurement: $(\mu_{Y3K1} - \mu_{Y3K2} - \mu_{Y3K3}) = (\mu_{Y2K1} - \mu_{Y2K2} - \mu_{Y2K3}) = (\mu_{Y1K1} - \mu_{Y1K2} - \mu_{Y1K3})$.

    (K = Key measurement and Y = Year)

For the alternative hypotheses, the statement will be generalized so that not all the groups have equal means for each of the hypotheses.

2. The statistical F-test for repeated measure is chosen because there are related trials on the dependant variable for *k* samples, accept the assumptions of analysis of variance, and have interval data.

3. Significance level. Let $\alpha = 0.05$ and
   - Key measurement d.f. = [numerator (key measurement) (k-1) = (4-1) = 3], [denominator (n-k) = (12 – 4) = 8] = Key Measurement (3,8)
   - Year rating d.f. = [numerator (Year Rating) (k-1) = (3-1) = 2], [denominator (n-k) = (12 – 4) = 8] = Year Rating (2,8)
   - Year rating by Key measurement d.f. = [numerator (Year Rating by Key Measurement) (k-1) = (3-1) = 2], [denominator (n-k) = (12 – 4) = 8] = Year Rating by Key Measurement (3,8)

This shows that: Key Measurement (3,8), Year Rating (2,8),Year Rating by Key Measurement (3,8)

4. The calculated values are shown in Table 8.2 as seen below.

Table 8.2: Data table for the key performance measurements

1: AVERAGE NUMBER OF FORCED MISSED TACKLES FOR THE TRY TO BE SCORED												
Log Position	1	2	3	4	5	6	7	8	9	10	11	12
2003	2.58	2.24	2.26	2.26	2.2	1.87	2.83	2.00	1.82	2.61	1.89	1.47
2004	2.36	2.64	1.45	2.25	2.58	2.17	2.29	1.43	2.05	1.59	2.00	1.23
2005	4.13	3.84	4.04	3.73	3.30	3.80	3.69	3.11	1.42	2.77	1.86	1.56
Total 2003 - 2005	9.07	8.72	7.75	8.24	8.08	7.84	8.81	6.54	5.29	6.97	5.75	4.26
2: AVERAGE TOTAL NUMBER OF COLLISIONS FOR A TRY TO BE SCORED												
Log Position	1	2	3	4	5	6	7	8	9	10	11	12
2003	7.12	5.24	5.53	5.23	5.40	4.23	6.11	4.60	4.71	5.61	4.78	3.53
2004	5.53	6.50	3.95	5.19	5.42	4.33	5.08	3.86	5.95	3.71	5.47	4.31
2005	7.38	7.23	7.12	7.09	6.74	7.25	6.81	6.00	3.16	5.46	4.00	3.44
Total 2003 - 2005	20.03	18.97	16.6	17.51	17.56	15.81	18.00	14.46	13.82	14.78	14.25	11.28
3: RATIO OF DOMINANT COLLISIONS versus PASSES EXECUTED WHEN A TRY IS SCORED												
Log Position	1	2	3	4	5	6	7	8	9	10	11	12
2003	1.65	1.31	1.14	1.02	1.19	1.28	1.05	0.97	1.08	1.01	0.92	0.9
2004	0.95	1.26	0.93	0.91	0.99	1.01	1.16	0.82	1.09	0.94	1.01	0.75
2005	1.95	1.48	2.05	1.70	1.16	1.42	1.50	1.50	0.87	1.14	0.77	0.92
Total 2003 - 2005	4.55	4.05	4.12	3.63	3.34	3.71	3.71	3.29	3.04	3.09	2.70	2.57
4: AVERAGE POSITIVE VELOCITY CHANGE OF DOMINANT COLLISIONS RESULTING IN A TRY BEING SCORED												
Log Position	1	2	3	4	5	6	7	8	9	10	11	12
2003	596.02	509.05	407.67	407.80	300.65	491.35	285.65	392.02	376.33	489.02	303.05	283.19
2004	504.73	538.47	499.13	483.54	448.85	572.16	448.15	428.58	461.12	397.34	414.00	451.09
2005	818.46	691.21	687.25	694.39	662.78	595.49	610.24	573.83	524.45	531.44	577.45	526.12
Total 2003 - 2005	639.73	579.57	531.35	528.58	470.76	553.00	448.01	464.81	453.96	472.60	431.50	420.13

Table 8.3: Data table summary for the key performance measurements

Log Position	Rating 2003	Rating 2004	Rating 2005	Key Figure	Log Position	Rating 2003	Rating 2004	Rating 2005	Key Figure
1	2.58	2.36	4.13	1	1	1.65	0.95	1.95	3
2	2.24	2.64	3.84	1	2	1.31	1.26	1.48	3
3	2.26	1.45	4.04	1	3	1.14	0.93	2.05	3
4	2.26	2.25	3.73	1	4	1.02	0.91	1.70	3
5	2.20	2.58	3.30	1	5	1.19	0.99	1.16	3
6	1.87	2.17	3.80	1	6	1.28	1.01	1.42	3
7	2.83	2.29	3.69	1	7	1.05	1.16	1.50	3
8	2.00	1.43	3.11	1	8	0.97	0.82	1.50	3
9	1.82	2.05	1.42	1	9	1.08	1.09	0.87	3
10	2.61	1.59	2.77	1	10	1.01	0.94	1.14	3
11	1.89	2.00	1.86	1	11	0.92	1.01	0.77	3
12	1.47	1.23	1.56	1	12	0.90	0.75	0.92	3
1	7.12	5.53	7.38	2	1	596.02	504.73	818.46	4
2	5.24	6.50	7.23	2	2	509.05	538.47	691.21	4
3	5.53	3.95	7.12	2	3	407.67	499.13	687.25	4
4	5.23	5.19	7.09	2	4	407.80	483.54	694.39	4
5	5.40	5.42	6.74	2	5	300.65	448.85	662.78	4
6	4.23	4.33	7.25	2	6	491.35	572.16	595.49	4
7	6.11	5.08	6.81	2	7	285.65	448.15	610.24	4
8	4.60	3.86	6.00	2	8	392.02	428.58	573.83	4
9	4.71	5.95	3.16	2	9	376.33	461.12	524.45	4
10	5.61	3.71	5.46	2	10	489.02	397.34	531.44	4
11	4.78	5.47	4.00	2	11	303.05	414.00	577.45	4
12	3.53	4.31	3.44	2	12	283.19	451.09	526.12	4

The statistical F = Between Group Variance / Within Group Variance = Mean square between / Mean square within

where,

Mean square between = Sum of Squares between / Degrees of freedom between

Mean square within = Sum of Squares within / Degrees of freedom within

$F = MS_b/MS_w$: Table 8.4 below shows the F - values that have been calculated for each null hypothesis.

Table 8.4: Model summary

Model Summary					
Hypotheses to test	d.f.	F value between 2003 and 2004	F value between 2004 and 2005	F value between 2003 and 2005	Measure of spread
Key Measurement	3	0.805	0.654	0.491	(3,8)
Year Rating	2	0.377	0.044	0.004	(2,8)
Year Rating by Key Measurement	3	0.035	0.074	0.803	(3,8)

5. Critical test value

   The d.f values are as following:

   Key Measurement (3,8), Year Rating (2,8),Year Rating by Key Measurement (3,8)

   Comparing these with a statistical table for critical values of the F distribution for $\alpha = 0.05$ the critical values are as following:

   - (3,8): 4.07
   - (2,8): 4.46
   - (3,8): 4.07

6. Interpretation

   The statistical results are grounds for accepting all three null hypotheses and concluding that there is a statistical significance of at least 95% with an alpha of 0.05 between the means in all three instances. This shows that the data that was captured for the twelve teams for all tries scored by these teams over a period of three years and for the four key measurements, have a statistical significance of 95% for the readings respectively. Figure 8.1 below shows the mean average differences for all three key measurements over the three-year period.

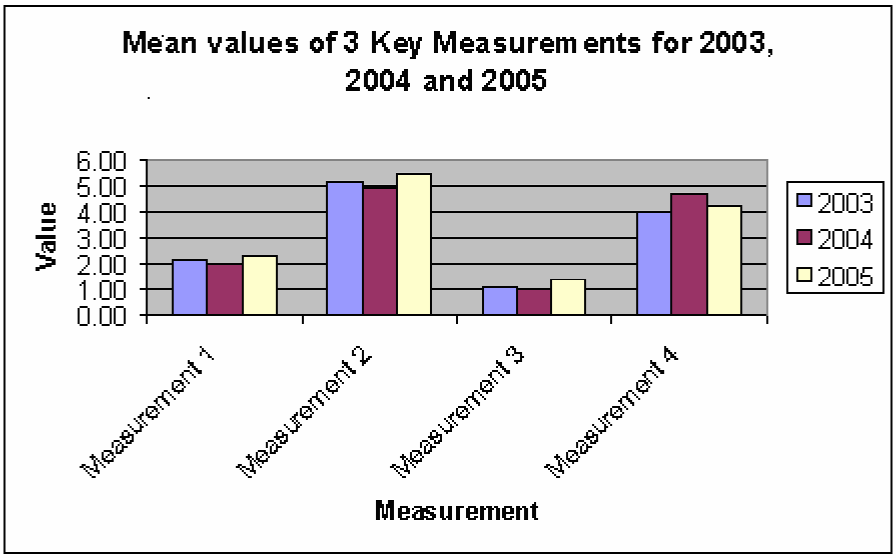


Figure 8.1: Mean values of the four key performance measurements for 2003, 2004 and 2005

8.7 Multivariate analysis

As the reliability and validity of the statistics has been established, the following step in the process is to interpret the information so that reasons and recommendations can be made concerning the statistics shown.

Making use of regression analysis and multiple regressions the correlation between log position and the four key measurements as well as the relation between these key measurements can clearly be seen in the tables and Figures that are to be shown.

Table 8.5: Total number of forced missed tackles vs total average number of collisions

	AVERAGE NUMBER OF FORCED MISSED TACKLES vs TOTAL AVERAGE NUMBER OF COLLISIONS												
	LOG POSITION	1	2	3	4	5	6	7	8	9	10	11	12
1	Average number of forced missed tackles – 2003	2.58	2.24	2.26	2.26	2.20	1.87	2.83	2.00	1.82	2.61	1.89	1.47
1	Average number of forced missed tackles – 2004	2.36	2.64	1.45	2.25	2.58	2.17	2.29	1.43	2.05	1.59	2.00	1.23
1	Average number of forced missed tackles – 2005	4.13	3.84	4.04	3.73	3.30	3.80	3.69	3.11	1.42	2.77	1.86	1.56
1	Average number of forced missed tackles – Total	9.07	8.72	7.75	8.24	8.08	7.84	8.81	6.54	5.29	6.97	5.75	4.26
	vs												
2	Average total number of collisions - 2003	7.12	5.24	5.53	5.23	5.40	4.23	6.11	4.60	4.71	5.61	4.78	3.53
2	Average total number of collisions – 2004	5.53	6.50	3.95	5.19	5.42	4.33	5.08	3.86	5.95	3.71	5.47	4.31
2	Average total number of collisions – 2005	7.38	7.23	7.12	7.09	6.74	7.25	6.81	6.00	3.16	5.46	4.00	3.44
2	Average total number of collisions – Total	20.03	18.97	16.6	17.51	17.56	15.81	18	14.46	13.82	14.78	14.25	11.28
	1: 2003 / 2: 2003	0.36236	0.42748	0.40868	0.43212	0.40741	0.44208	0.46318	0.43478	0.38641	0.46524	0.3954	0.41643
	1: 2004 / 2: 2004	0.42676	0.40615	0.36709	0.43353	0.47601	0.50115	0.45079	0.37047	0.34454	0.42857	0.36563	0.28538
	1: 2005 / 2: 2005	0.55962	0.53112	0.56742	0.52609	0.48961	0.52414	0.54185	0.51833	0.44937	0.50733	0.465	0.45349
	1: TOTAL / 2: TOTAL	0.45282	0.45967	0.46687	0.47059	0.46014	0.49589	0.48944	0.45228	0.38278	0.47158	0.40351	0.37766

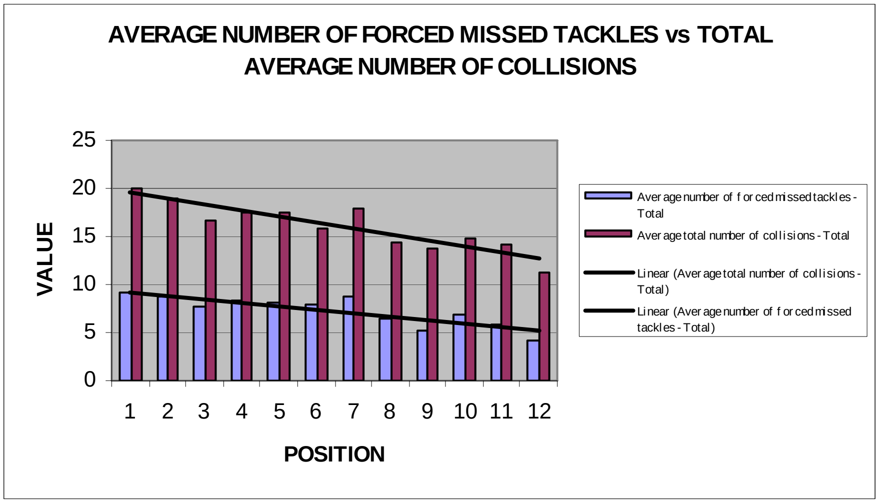


Figure 8.2: Average number of forced missed tackles vs total average number of collisions

As is evident from Table 8.5 and Figure 8.2, teams that are more successful and that finish higher on the log have a higher rate of forced missed tackles as well as a higher rate of total average number of collisions. A reason for this could be attributed to the fact that a team that executes more collisions while scoring a try will have more opportunities to force more missed tackles. The fact that more collisions take place also indicates that the team is able to dominate the opposition in terms of their ability to run at defensive lines that have been constantly tested thus making them vulnerable and more likely to make defensive errors. These two factors are interrelated as they both become lower as the teams are lower on the log.

Table 8.6: Total number of forced missed tackles vs average positive velocity change of dominant collisions

AVERAGE NUMBER OF FORCED MISSED TACKLES vs AVERAGE POSITIVE VELOCITY CHANGE OF DOMINANT COLLISIONS

	LOG POSITION	1	2	3	4	5	6	7	8	9	10	11	12
1	Average number of forced missed tackles - 2003	2.58	2.24	2.26	2.26	2.2	1.87	2.83	2.00	1.82	2.61	1.89	1.47
1	Average number of forced missed tackles - 2004	2.36	2.64	1.45	2.25	2.58	2.17	2.29	1.43	2.05	1.59	2.00	1.23
1	Average number of forced missed tackles - 2005	4.13	3.84	4.04	3.73	3.30	3.80	3.69	3.11	1.42	2.77	1.86	1.56
1	Average number of forced missed tackles - Total	9.07	8.72	7.75	8.24	8.08	7.84	8.81	6.54	5.29	6.97	5.75	4.26
	vs												
2	Average positive velocity change of dominant collisions - 2003	596	509.1	407.7	407.8	300.7	491.4	285.7	392.02	376.3	489	303.1	283.2
2	Average positive velocity change of dominant collisions - 2004	504.7	538.47	499.13	483.54	448.85	572.16	448.2	428.6	461.1	397.3	414.00	451.1
2	Average positive velocity change of dominant collisions - 2005	818.5	691.2	687.3	694.4	662.78	595.49	610.24	573.83	524.45	531.44	577.45	526.1
2	Average positive velocity change of dominant collisions - Total	639.7	579.6	531.4	528.6	470.8	553	448	464.8	454	472.6	431.5	420.1
2	Average positive velocity change of dominant collisions / 100	6.397	5.796	5.314	5.286	4.708	5.53	4.48	4.648	4.54	4.726	4.315	4.201
	1: 2003 / 2: 2003	0.00433	0.0044	0.00554	0.00554	0.00732	0.00381	0.00991	0.0051	0.00484	0.00534	0.00624	0.00519
	1: 2004 / 2: 2004	0.00468	0.0049	0.00291	0.00465	0.00575	0.00379	0.00511	0.00334	0.00445	0.004	0.00483	0.00273
	1: 2005 / 2: 2005	0.00505	0.00556	0.00588	0.00537	0.00498	0.00638	0.00605	0.00542	0.00271	0.00521	0.00322	0.00297
	1: TOTAL / 2: TOTAL	0.01418	0.01505	0.01459	0.01559	0.01716	0.01418	0.01966	0.01407	0.01165	0.01475	0.01333	0.01014

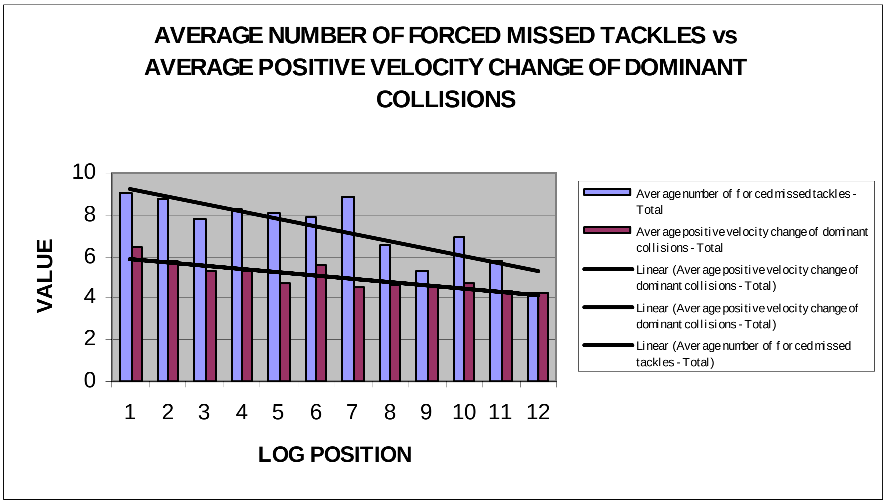


Figure 8.3: Average number of forced missed tackles vs average positive velocity change of dominant collisions

As is evident from Table 8.6 and Figure 8.3, teams that are more successful and that finish higher on the log have a higher rate of forced missed tackles as well as a higher rate of average positive velocity change of dominant collisions.

The higher average positive velocity change of dominant collisions is an indicator of a team’s ability to dominate the defender in terms of running into the defender with a greater average momentum than what the defender can bring into the collision situation. This greater momentum into the collision by the ball carrier will most definitely impact on the number of missed tackles made by the defenders as they are not able to impact effectively when executing the tackle. The defender is thus more likely to be knocked over when trying to make the tackle. These two factors are interrelated as they both become lower as the teams are lower on the log.

Table 8.7: Average number of forced missed tackles vs ratio of dominant collision versus passes executed

	AVERAGE NUMBER OF FORCED MISSED TACKLES vs RATIO OF DOMINANT COLLISIONS VERSUS PASSES EXECUTED												
	LOG POSITION	1	2	3	4	5	6	7	8	9	10	11	12
1	Average number of forced missed tackles - 2003	2.58	2.24	2.26	2.26	2.2	1.87	2.83	2.00	1.82	2.61	1.89	1.47
1	Average number of forced missed tackles - 2004	2.36	2.64	1.45	2.25	2.58	2.17	2.29	1.43	2.05	1.59	2.00	1.23
1	Average number of forced missed tackles - 2005	4.13	3.84	4.04	3.73	3.30	3.80	3.69	3.11	1.42	2.77	1.86	1.56
1	Average number of forced missed tackles - Total	9.07	8.72	7.75	8.24	8.08	7.84	8.81	6.54	5.29	6.97	5.75	4.26
	vs												
2	Ratio of dominant collisions vs passes executed - 2003	1.65	1.31	1.14	1.02	1.19	1.28	1.05	0.97	1.08	1.01	0.92	0.9
2	Ratio of dominant collisions vs passes executed - 2004	0.95	1.26	0.93	0.91	0.99	1.01	1.16	0.82	1.09	0.94	1.01	0.75
2	Ratio of dominant collisions vs passes executed - 2005	1.95	1.48	2.05	1.7	1.16	1.42	1.50	1.50	0.87	1.14	0.77	0.92
2	Ratio of dominant collisions vs passes executed - Total	4.55	4.05	4.12	3.63	3.34	3.71	3.71	3.29	3.04	3.09	2.7	2.57
	1: 2003 / 2: 2003	1.563636	1.709924	1.982456	2.215686	1.848739	1.460938	2.695238	2.061856	1.685185	2.584158	2.054348	1.633333
	1: 2004 / 2: 2004	2.484211	2.095238	1.55914	2.472527	2.606061	2.148515	1.974138	1.743902	1.880734	1.691489	1.980198	1.64
	1: 2005 / 2: 2005	2.117949	2.594595	1.970732	2.194118	2.844828	2.676056	2.46	2.073333	1.632184	2.429825	2.415584	1.695652
	1: TOTAL / 2: TOTAL	1.993407	2.153086	1.881068	2.269972	2.419162	2.113208	2.374663	1.987842	1.740132	2.255663	2.12963	1.657588

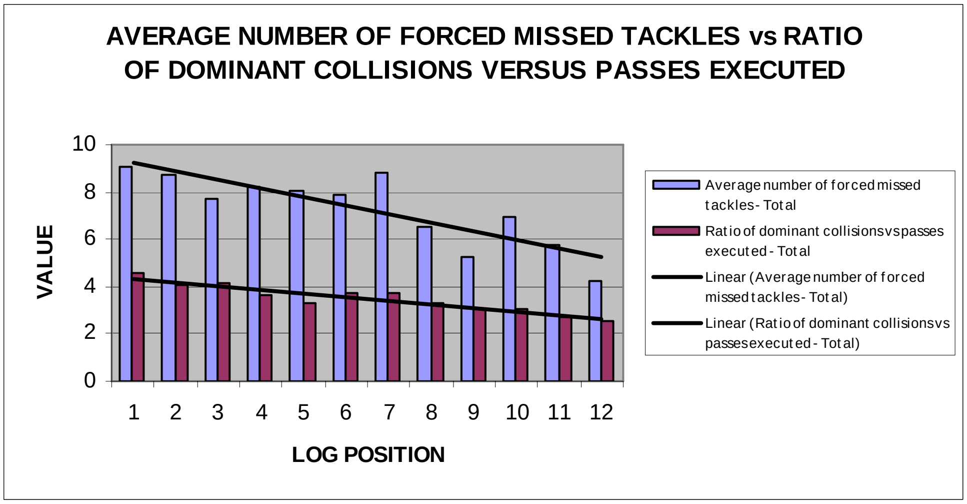


Figure 8.4: Average number of forced missed tackles vs ratio of dominant collisions versus passes executed

As is evident from Table 8.7 and Figure 8.4, teams that are more successful and that finish higher on the log have a higher rate of forced missed tackles as well as a higher ratio of dominant collisions versus passes executed. The ratio of dominant collisions versus passes executed is an indicator of a team's ability to move upwards down the filed of play towards the opposition's try line compared to the team's willingness to move the ball around making use of passes along the field in order to try and do so.

This implies that a team with a higher ratio of dominant collisions versus passes executed is more likely to be confrontational and tends to move forward and run at the opposition than what a team would do that passes the ball more often. The teams that have a lower ratio of dominant collisions versus passes executed attempts to score tries by passing the ball more often in their attempt to shy away from collisions.

Teams that are inclined to run more at the opposition also thus tend to be able to force more missed tackles onto the opposition thus making it more difficult for the defenders to consistently make their tackles. These two factors are interrelated as they both become lower as the teams are lower on the log.

Table 8.8: Total average number of collisions vs average positive velocity change of dominant collisions

	TOTAL AVERAGE NUMBER OF COLLISIONS vs AVERAGE POSITIVE VELOCITY CHANGE OF DOMINANT COLLISIONS												
	LOG POSITION	1	2	3	4	5	6	7	8	9	10	11	12
1	Average number of collisions – 2003	7.12	5.24	5.53	5.23	5.4	4.23	6.11	4.60	4.71	5.61	4.78	3.53
1	Average number of collisions – 2004	5.53	6.50	3.95	5.19	5.42	4.33	5.08	3.86	5.95	3.71	5.47	4.31
1	Average number of collisions – 2005	7.38	7.23	7.12	7.09	6.74	7.25	6.81	6.00	3.16	5.46	4.00	3.44
1	Average number of collisions – Total	20.03	18.97	16.6	17.51	17.56	15.81	18	14.46	13.82	14.78	14.25	11.28
	vs												
2	Average positive velocity change of dominant collisions - 2003	596	509.1	407.7	407.8	300.7	491.4	285.7	392.02	376.3	489	303.1	283.2
2	Average positive velocity change of dominant collisions - 2004	504.7	538.47	499.13	483.54	448.85	572.16	448.2	428.6	461.1	397.3	414.00	451.1
2	Average positive velocity change of dominant collisions - 2005	818.5	691.2	687.3	694.4	662.78	595.49	610.24	573.83	524.45	531.44	577.45	526.1
2	Average positive velocity change of dominant collisions - Total	639.7	579.6	531.4	528.6	470.8	553	448	464.8	454	472.6	431.5	420.1
2	Average positive velocity change of dominant collisions / 100	6.397	5.796	5.314	5.286	4.708	5.53	4.48	4.648	4.54	4.726	4.315	4.201
	1: 2003 / 2: 2003	0.01195	0.01029	0.01356	0.01282	0.01796	0.00861	0.02139	0.01173	0.01252	0.01147	0.01577	0.01247
	1: 2004 / 2: 2004	0.01096	0.01207	0.00791	0.01073	0.01208	0.00757	0.01134	0.00901	0.0129	0.00934	0.01321	0.00955
	1: 2005 / 2: 2005	0.00902	0.01046	0.01036	0.01021	0.01017	0.01217	0.01116	0.01046	0.00603	0.01027	0.00693	0.00654
	1: TOTAL / 2: TOTAL	0.03131	0.03273	0.03124	0.03313	0.0373	0.02859	0.04018	0.03111	0.03044	0.03127	0.03302	0.02685

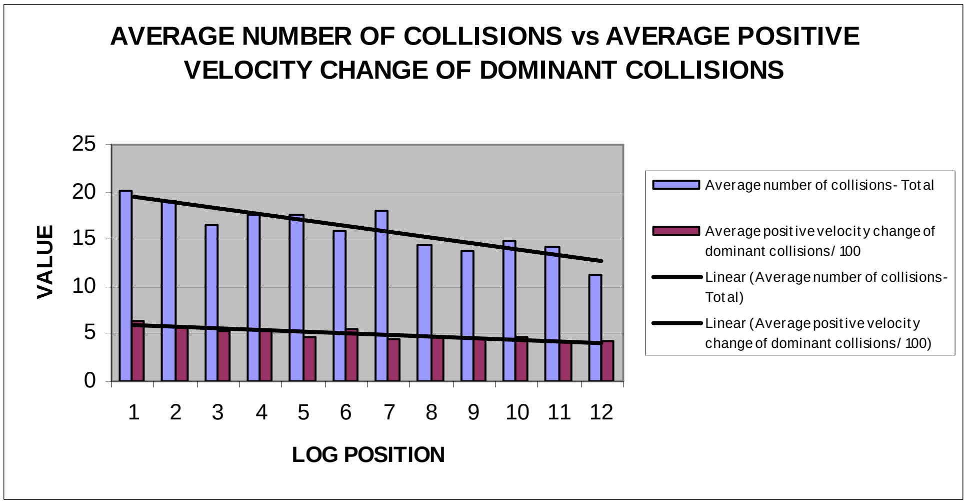


Figure 8.5: Average number of collisions vs average positive velocity change of dominant collisions

As is evident from Table 8.8 and Figure 8.5, teams that are more successful and that finish higher on the log have a higher rate of average number of collisions versus average positive velocity change of dominant collisions. In order for a team to be able to optimally dominate collisions, a crucial component is the team's ability to run hard into the collision site with a higher average positive velocity change. If this is done with repeated regularity, as is indicated by the higher average number of collisions, it thus becomes obvious that these two factors in combination positively affect a team's ability to score a try. As indicated in Figure 8.5, there is a strong correlation between the two factors which indicates that the teams with higher values are most definitely more likely to be successful in their matches that they play. These two factors are interrelated as they both become lower as the teams are lower on the log.

Table 8.9: Total average number of collisions vs ratio of dominant collisions versus passes executed

	TOTAL AVERAGE NUMBER OF COLLISIONS vs RATIO OF DOMINANT COLLISIONS VERSUS PASSES EXECUTED												
	LOG POSITION	1	2	3	4	5	6	7	8	9	10	11	12
1	Average number of collisions – 2003	7.12	5.24	5.53	5.23	5.40	4.23	6.11	4.60	4.71	5.61	4.78	3.53
1	Average number of collisions – 2004	5.53	6.50	3.95	5.19	5.42	4.33	5.08	3.86	5.95	3.71	5.47	4.31
1	Average number of collisions – 2005	7.38	7.23	7.12	7.09	6.74	7.25	6.81	6.00	3.16	5.46	4.00	3.44
1	Average number of collisions – Total	20.03	18.97	16.60	17.51	17.56	15.81	18.00	14.46	13.82	14.78	14.25	11.28
	vs												
2	Ratio of dominant collisions vs passes executed - 2003	1.65	1.31	1.14	1.02	1.19	1.28	1.05	0.97	1.08	1.01	0.92	0.90
2	Ratio of dominant collisions vs passes executed - 2004	0.95	1.26	0.93	0.91	0.99	1.01	1.16	0.82	1.09	0.94	1.01	0.75
2	Ratio of dominant collisions vs passes executed - 2005	1.95	1.48	2.05	1.7	1.16	1.42	1.50	1.50	0.87	1.14	0.77	0.92
2	Ratio of dominant collisions vs passes executed - Total	4.55	4.05	4.12	3.63	3.34	3.71	3.71	3.29	3.04	3.09	2.70	2.57
	1: 2003 / 2: 2003	4.31515	4.00000	4.85088	5.12745	4.53782	3.30469	5.81905	4.74227	4.36111	5.55446	5.19565	3.92222
	1: 2004 / 2: 2004	5.82105	5.15873	4.24731	5.7033	5.47475	4.28713	4.37931	4.70732	5.45872	3.94681	5.41584	5.74667
	1: 2005 / 2: 2005	3.78462	4.88514	3.47317	4.17059	5.81034	5.10563	4.54000	4.00000	3.63218	4.78947	5.19481	3.73913
	1: TOTAL / 2: TOTAL	4.4022	4.68395	4.02913	4.82369	5.25749	4.26146	4.85175	4.39514	4.54605	4.78317	5.27778	4.38911

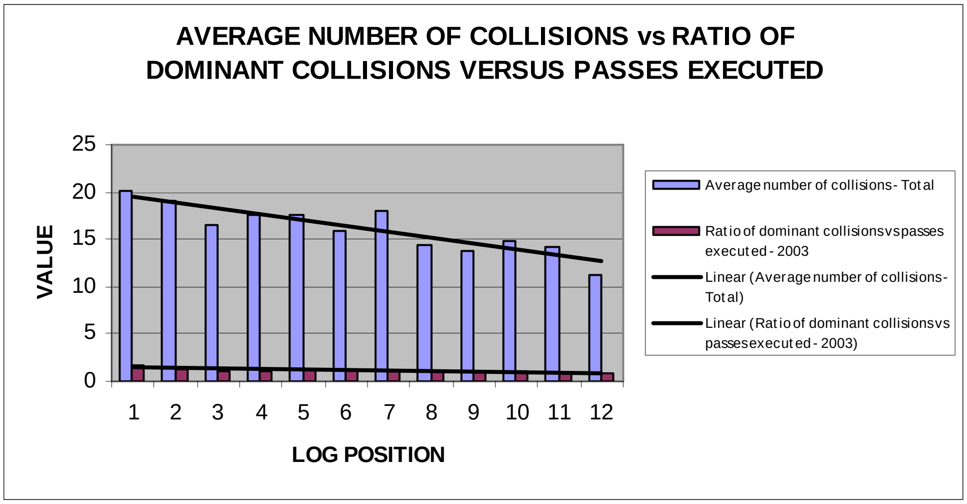


Figure 8.6: Average number of collisions vs ratio of dominant collisions versus passes executed

As is evident from Table 8.9 and Figure 8.6, teams that are more successful and that finish higher on the log have a higher average number of collisions versus ratio of dominant collisions versus passes executed.

The correlation between these two factors indicates that teams that focus more on running hard and effectively at the opposition are more likely to dominate collisions and thus be more successful in the matches that they have played. The number of collisions taking place is higher thus the team is more physically dominant at the collision site and is thus more successful.

These two factors are interrelated as they both become lower as the teams are lower on the log.

Table 8.10: Ratio of dominant collisions versus passes executed vs average positive velocity change

	RATIO OF DOMINANT COLLISIONS VERSUS PASSES EXECUTED vs AVERAGE POSITIVE VELOCITY CHANGE												
	LOG POSITION	1	2	3	4	5	6	7	8	9	10	11	12
1	Ratio of dominant collisions vs passes executed - 2003	1.65	1.31	1.14	1.02	1.19	1.28	1.05	0.97	1.08	1.01	0.92	0.9
1	Ratio of dominant collisions vs passes executed - 2004	0.95	1.26	0.93	0.91	0.99	1.01	1.16	0.82	1.09	0.94	1.01	0.75
1	Ratio of dominant collisions vs passes executed - 2005	1.95	1.48	2.05	1.7	1.16	1.42	1.50	1.50	0.87	1.14	0.77	0.92
1	Ratio of dominant collisions vs passes executed - Total	4.55	4.05	4.12	3.63	3.34	3.71	3.71	3.29	3.04	3.09	2.70	2.57
	vs												
2	Average positive velocity change of dominant collisions - 2003	596.0	509.1	407.7	407.8	300.7	491.4	285.7	392.02	376.3	489.0	303.1	283.2
2	Average positive velocity change of dominant collisions - 2004	504.7	538.47	499.13	483.54	448.85	572.16	448.2	428.6	461.1	397.3	414.00	451.1
2	Average positive velocity change of dominant collisions - 2005	818.5	691.2	687.3	694.4	662.78	595.49	610.24	573.83	524.45	531.44	577.45	526.1
2	Average positive velocity change of dominant collisions - Total	639.7	579.6	531.4	528.6	470.8	553	448	464.8	454	472.6	431.5	420.1
2	Average positive velocity change of dominant collisions / 100	6.397	5.796	5.314	5.286	4.708	5.53	4.48	4.648	4.54	4.726	4.315	4.201
	1: 2003 / 2: 2003	0.00277	0.00257	0.0028	0.0025	0.00396	0.00261	0.00368	0.00247	0.00287	0.00207	0.00304	0.00318
	1: 2004 / 2: 2004	0.00188	0.00234	0.00186	0.00188	0.00221	0.00177	0.00259	0.00191	0.00236	0.00237	0.00244	0.00166
	1: 2005 / 2: 2005	0.00238	0.00214	0.00298	0.00245	0.00175	0.00238	0.00246	0.00261	0.00166	0.00215	0.00133	0.00175
	1: TOTAL / 2: TOTAL	0.00711	0.00699	0.00775	0.00687	0.00709	0.00671	0.00828	0.00708	0.0067	0.00654	0.00626	0.00612

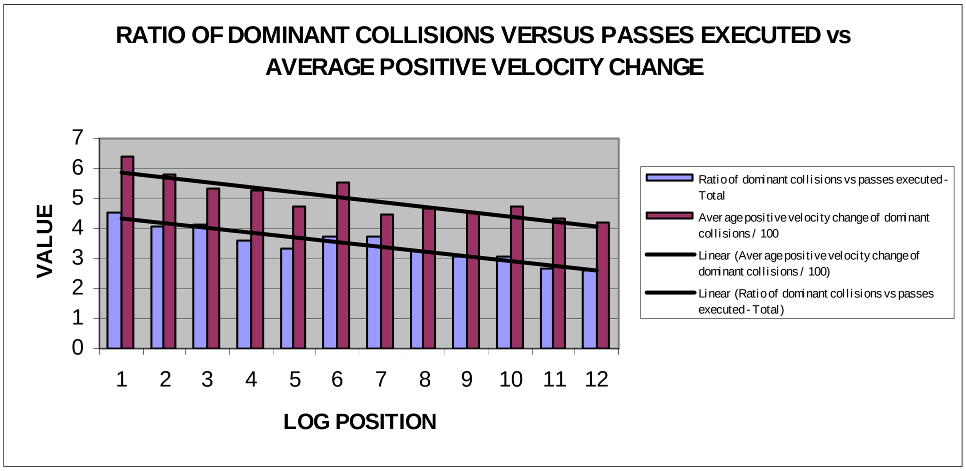


Figure 8.7: Ratio of dominant collisions versus passes executed vs average positive velocity change of dominant collisions

As is evident from Table 8.10 and Figure 8.7, teams that are more successful and that finish higher on the log have a higher ratio of dominant collisions versus passes executed versus average positive velocity change.

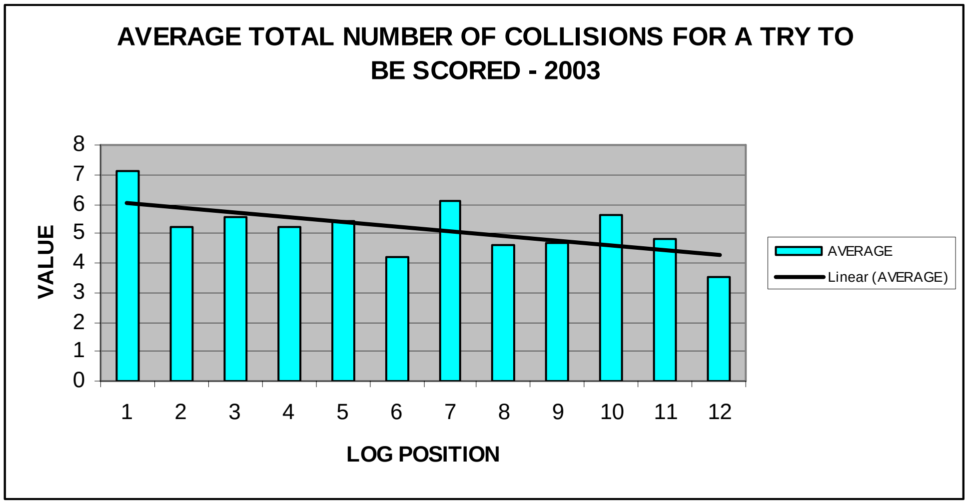
These two factors show a correlation that the teams that are able to dominate collisions better in terms of their ability to carry a higher average momentum into the collision as well as their focus on moving forward at the defenders, most definitely results in a more successful team. They are more able to physically confront the defensive opposition and thus dominate the defenders.

These two factors are interrelated as they both become lower as the teams are lower on the log.

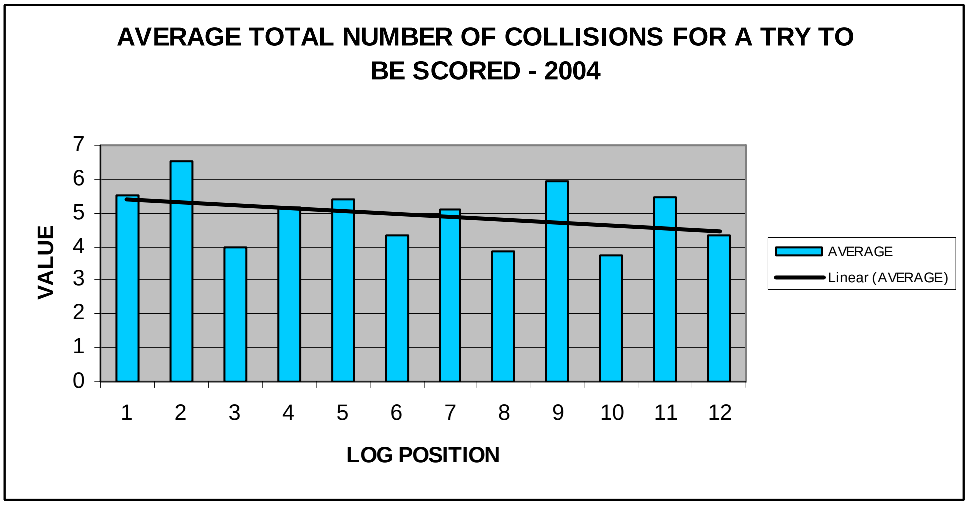
Table 8.11: Average total number of collisions for a try to be scored

AVERAGE TOTAL NUMBER OF COLLISIONS FOR A TRY TO BE SCORED												
2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLUES	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHI	SHA	CATS
AVERAGE	7.12	5.24	5.53	5.23	5.40	4.23	6.11	4.60	4.71	5.61	4.78	3.53
2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHI	BLUES	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
AVERAGE	5.53	6.50	3.95	5.19	5.42	4.33	5.08	3.86	5.95	3.71	5.47	4.31
2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHI	BLUES	HIGH	STO	REDS	CATS	SHA
AVERAGE	7.38	7.23	7.12	7.09	6.74	7.25	6.81	6.00	3.16	5.46	4.00	3.44

(a)



(b)



(c)

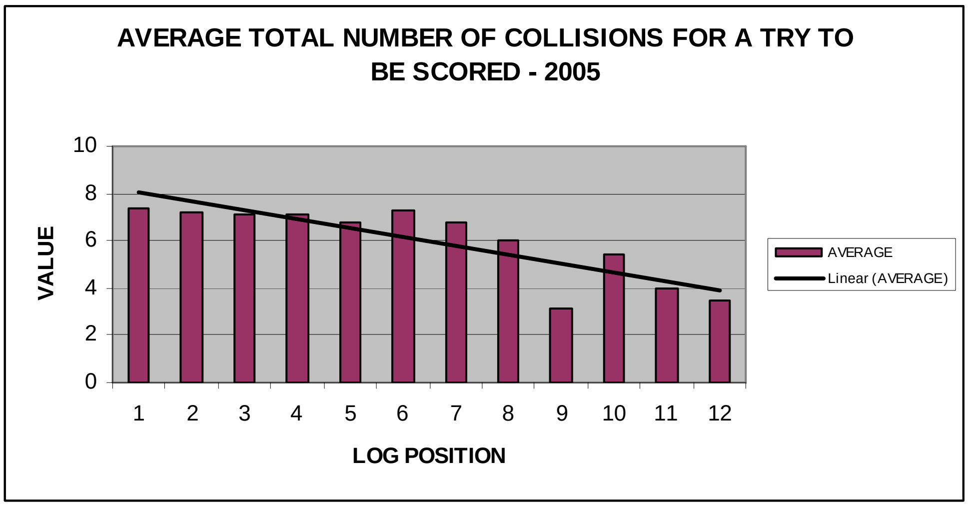


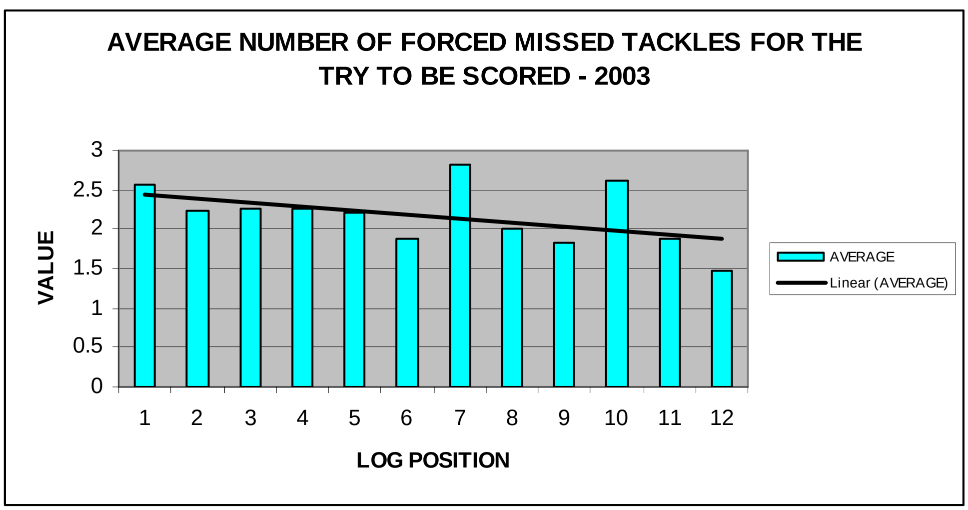
Figure 8.8 (a,b,c): Average total number of collisions for a try to be scored (2003, 2004 and 2005)

When Table 8.11 and Figures 8.8 (a,b,c) were evaluated it indicated that teams that are placed higher on the log statistically, made more dominant collisions in their attacking play before a try was scored. This could be due to various reasons, for example, with more dominant collisions, the attacking team was able to get more effective forward momentum, this in turn makes it difficult for the defending team to be able to fold effectively in term the attacking team was able to run hard at the opposition and be more effective at "hitting" the defender.

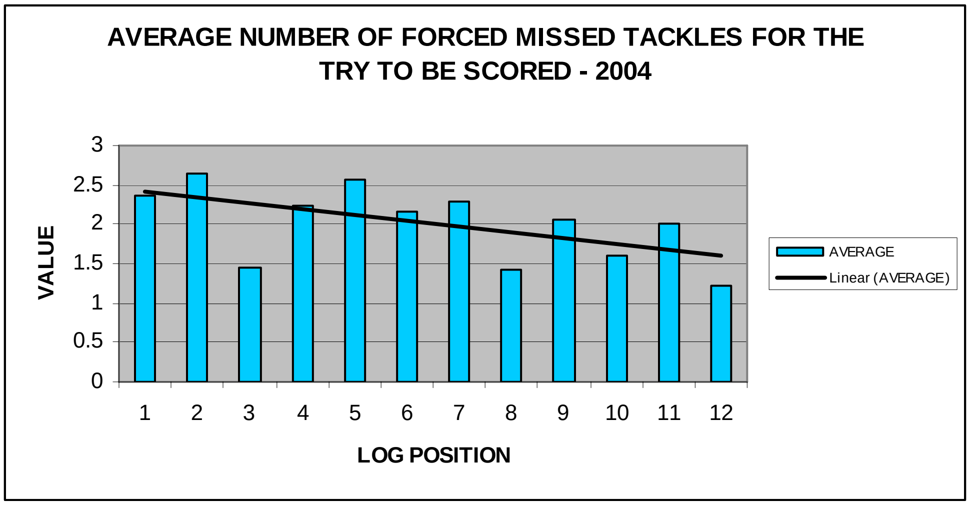
Table 8.12: Average number of forced missed tackles for the try to be scored

AVERAGE NUMBER OF FORCED MISSED TACKLES FOR THE TRY TO BE SCORED												
2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLUES	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHI	SHA	CATS
AVERAGE	2.58	2.24	2.26	2.26	2.20	1.87	2.83	2.00	1.82	2.61	1.89	1.47
2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHI	BLUES	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
AVERAGE	2.36	2.64	1.45	2.25	2.58	2.17	2.29	1.43	2.05	1.59	2.00	1.23
2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHI	BLUES	HIGH	STO	REDS	CATS	SHA
AVERAGE	4.13	3.84	4.04	3.73	3.30	3.80	3.69	3.11	1.42	2.77	1.86	1.56

(a)



(b)



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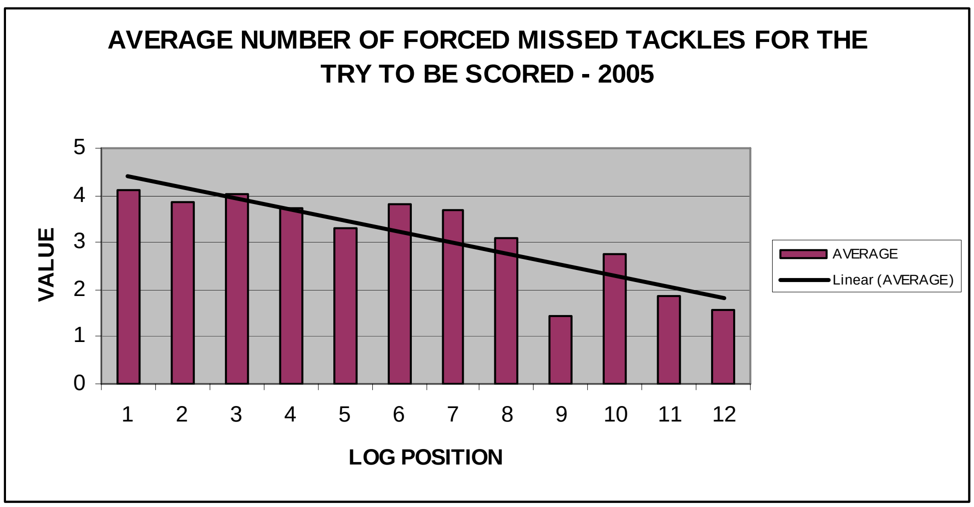


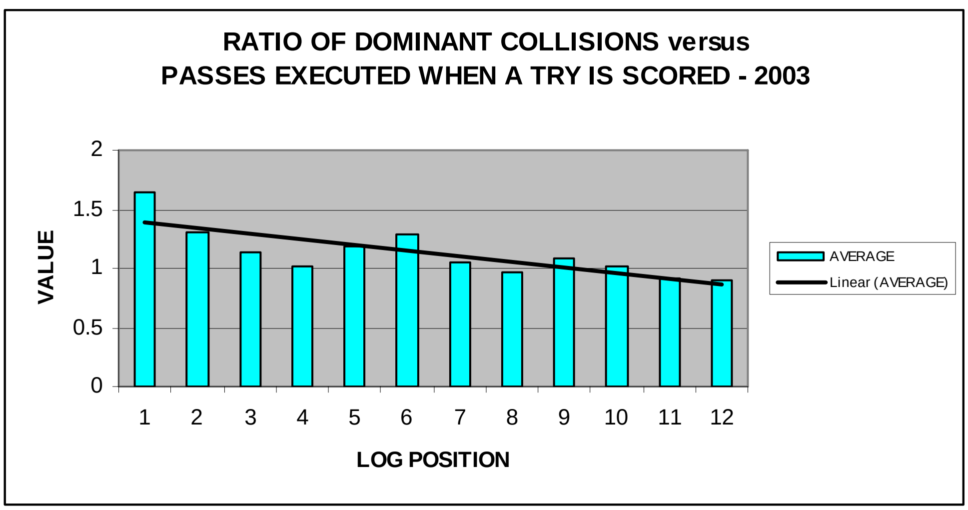
Figure 8.9 (a,b,c): Average number of forced missed tackles for the try to be scored (2003, 2004 and 2005)

After evaluation of Table 8.12 and Figures 8.9 (a,b,c), it becomes evident that those teams that were placed higher up on the log, forced more missed tackles onto the opposition during attacking play when scoring the try.

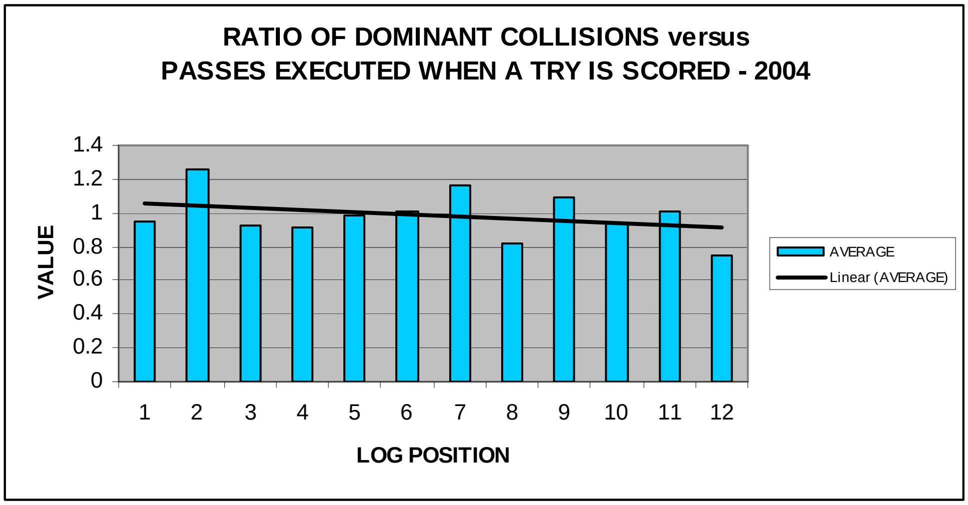
Table 8.13: Ratio of dominant collisions versus passes executed when a try is scored

RATIO OF DOMINANT COLLISIONS versus PASSES EXECUTED WHEN A TRY IS SCORED												
2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLUES	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHIEFS	SHA	CATS
AVERAGE	1.65	1.31	1.14	1.02	1.19	1.28	1.05	0.97	1.08	1.01	0.92	0.9
2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHIEFS	BLUES	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
AVERAGE	0.95	1.26	0.93	0.91	0.99	1.01	1.16	0.82	1.09	0.94	1.01	0.75
2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHIEFS	BLUES	HIGH	STO	REDS	CATS	SHA
AVERAGE	1.95	1.48	2.05	1.70	1.16	1.42	1.50	1.50	0.87	1.14	0.77	0.92

(a)



(b)



(c)

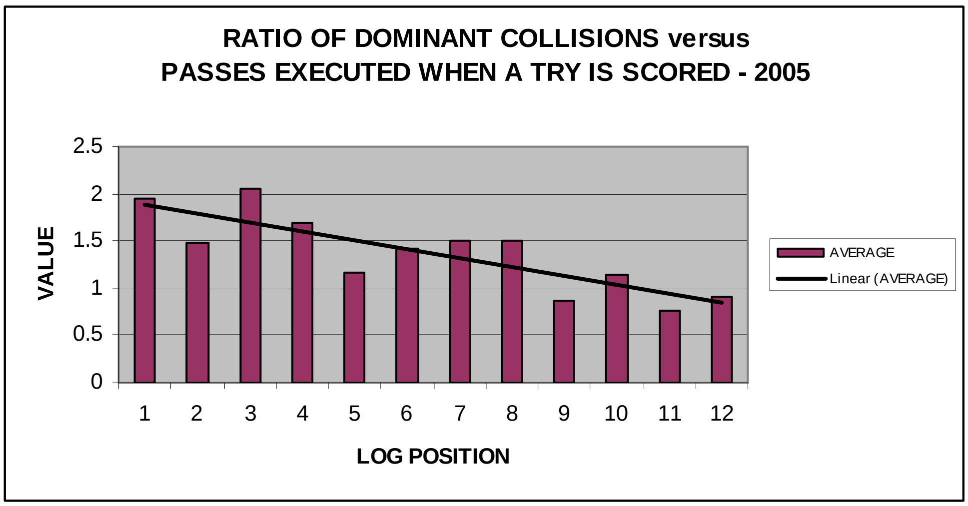


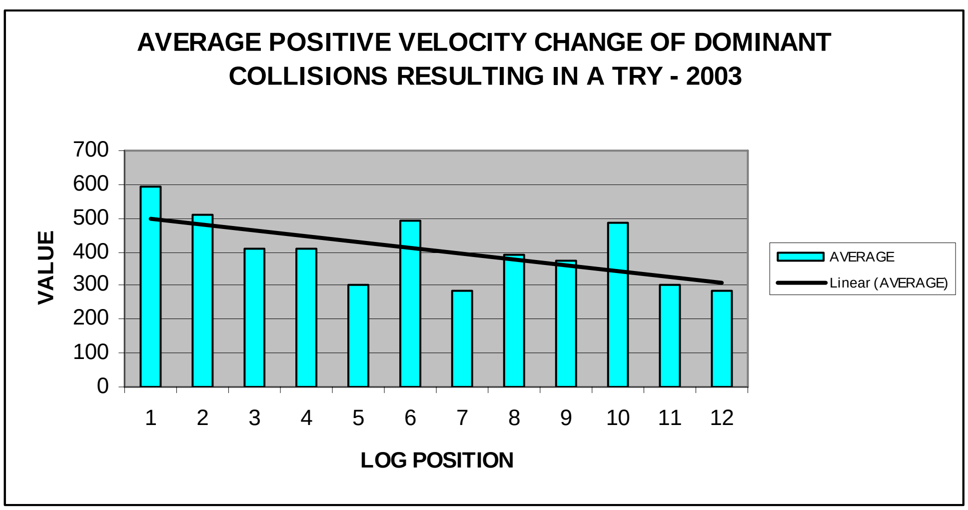
Figure 8.10 (a,b,c): Ratio of dominant collisions versus passes executed when a try is scored (2003, 2004 and 2005)

After evaluation of Table 8.13 and Figures 8.10 (a,b,c), the following tendency was identified. The teams that finished higher on the log had a higher ratio of collisions when compared with the number of passes that were executed. When the team had a ratio of above one, this was an indication that those teams made more dominant collisions than passes for their tries to be scored. It becomes obvious that those teams that placed higher on the log had a markedly higher value above 1 and those teams that were under 0 were markedly lower on the log.

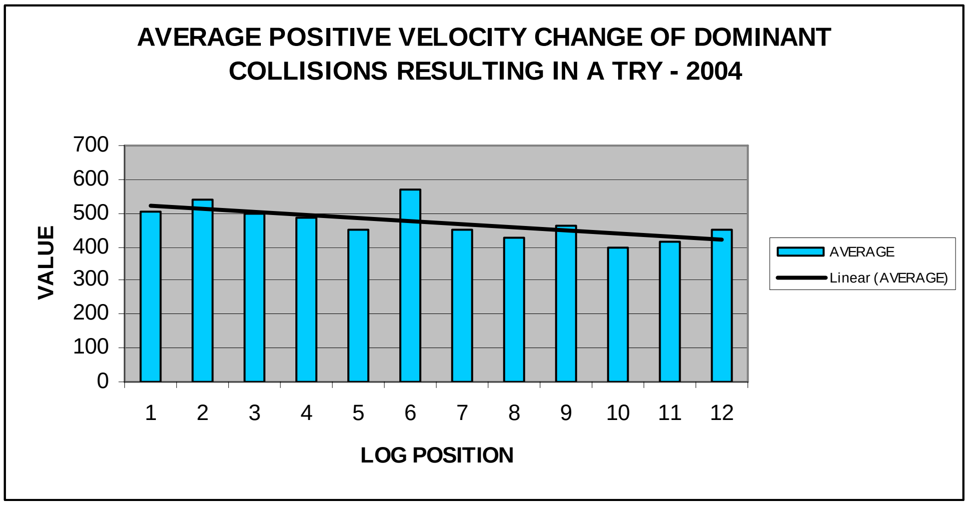
Table 8.14: Average positive velocity change of dominant collisions resulting in a try being scored

AVERAGE POSITIVE VELOCITY CHANGE OF DOMINANT COLLISIONS RESULTING IN A TRY												
2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLUES	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHIEFS	SHA	CATS
AVERAGE	596.02	509.05	407.67	407.80	300.65	491.35	285.65	392.02	376.33	489.02	303.05	283.19
2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHIEFS	BLUES	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
AVERAGE	504.73	538.47	499.13	483.54	448.85	572.16	448.15	428.58	461.12	397.34	414.00	451.09
2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHIEFS	BLUES	HIGH	STO	REDS	CATS	SHA
AVERAGE	818.46	691.21	687.25	694.39	662.78	595.49	610.24	573.83	524.45	531.44	577.45	526.12

(a)



(b)



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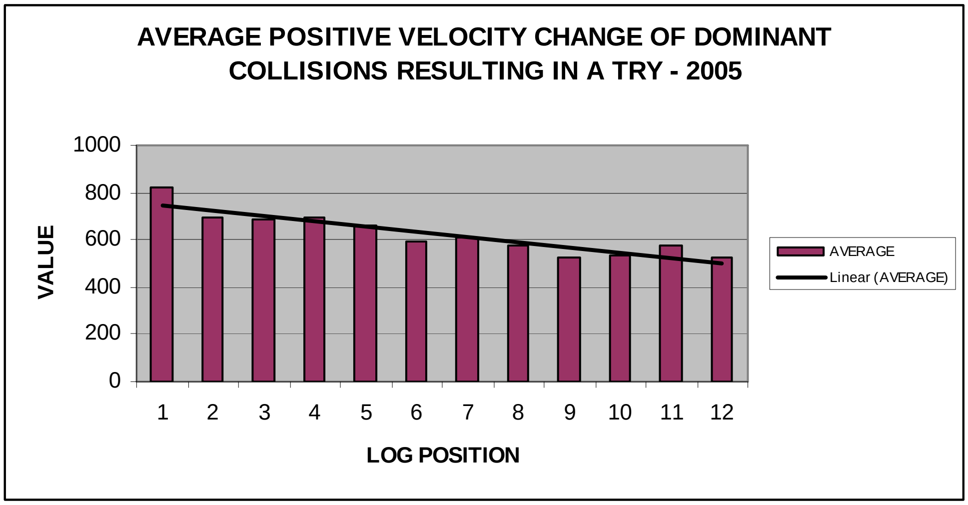


Figure 8.11 (a,b,c): Average positive velocity change of dominant collisions resulting in a try being scored (2003, 2004 and 2005)

After evaluating Table 8.14 and Figure 8.11 (a,b,c), it is noticeable that those teams that finished higher on the log statistically have a higher average positive velocity change than those teams that finished lower on the log when a try was scored. This indicates that those teams that dominated the collision site with a greater force were more successful on the log.

8.8 Cross tabulation of the data

The final stage of the statistical analysis is a cross tabulation of the respective data. The data is compared from the year 2003 to 2005 and indicates the relative percentage changes of the key performance measurements.

As can be seen from Tables 8.15(a), 8.15(b), and 8.16 there is without doubt a strong correlation between the increases in percentage change of teams that are higher on the log than those teams that are placed lower down on the log.

The teams that showed a greater increased change in the key performance measurements were more inclined to improve their success and thus performed better in the relevant competitions.

Table 8.15 (a): Rate of change in collisions between teams ranked from position 1 through to 6; 2003-2005

RATE OF CHANGE 2003 - 2005 POSITION 1 - 6																		
2003	CRUSADERS			BLUES			HURRICANES			ACT			NSW			BULLS		
Average forced missed tackles	2.58			2.2			2.26			2.3			2.2			1.9		
Average number of collisions	7.12			5.2			5.53			5.2			5.4			4.2		
Ratio of collisions vs passes	1.65			1.3			1.14			1			1.19			1.3		
Average positive velocity change/100	5.96			5.1			4.08			4.1			3.01			4.9		
2004	CRUSADERS			BLUES			HURRICANES			ACT			NSW			BULLS		
Average forced missed tackles	2.64	2.3%		2.6	15.2%		2	-11.5%		2.4	4.4%		2.29	4.1%		2.2	16.0%	
Average number of collisions	6.5	-8.7%		5.4	3.4%		5.47	-1.1%		5.5	5.7%		5.08	-5.9%		4.3	2.4%	
Ratio of collisions vs passes	1.26	-23.6%		1	-24.4%		1.01	-11.4%		1	-6.9%		1.16	-2.5%		1	-21.1%	
Average positive velocity change/100	5.38	-9.7%		4.5	-11.8%		4.14	1.6%		5	23.8%		4.48	49.1%		5.7	16.4%	
2005	CRUSADERS			BLUES			HURRICANES			ACT			NSW			BULLS		
Average forced missed tackles	4.13	56.4%	60.1%	3.7	43.0%	64.7%	3.73	86.5%	65.0%	3.3	39.8%	46.0%	3.84	67.7%	74.5%	4	86.2%	116.0%
Average number of collisions	7.38	13.5%	3.7%	6.8	25.6%	30.0%	7.09	29.6%	28.2%	6.7	21.9%	28.9%	7.23	42.3%	33.9%	7.1	64.4%	68.3%
Ratio of collisions vs passes	1.95	54.8%	18.2%	1.5	51.5%	14.5%	1.7	68.3%	49.1%	1.2	22.1%	13.7%	1.48	27.6%	24.4%	2.1	103.0%	60.2%
Average positive velocity change/100	8.18	52.0%	37.3%	6.1	36.0%	19.9%	6.94	67.7%	70.3%	6.6	31.3%	62.5%	6.91	54.2%	129.9%	6.9	20.1%	39.9%

	CRUSADERS	BLUES	HURRICANES	ACT	NSW	BULLS
Position 2003	1	2	3	4	5	6
Position 2004	2	5	11	1	7	6
Position 2005	1	7	4	5	2	3
Position - Average	1	5	6	3	5	5
Class A changes 2003 - 2004	0	0	0	0	1	0
Class B changes 2003 - 2004	0	0	0	0	0	0
Class A changes 2004 - 2005	3	3	1	2	1	1
Class B changes 2004 - 2005	0	0	2	0	1	2
Class A changes 2003 - 2005	1	1	1	1	1	1
Class B changes 2003 - 2005	1	1	2	1	2	3
Total Class A changes	4	4	2	3	3	2
Total Class B changes	1	1	4	1	3	5
Total Changes	5	5	6	4	6	7

Table 8.15 (b): Rate of change in collisions between teams ranked from position 7 through to 12; 2003-2005

RATE OF CHANGE 2003 - 2005	POSITION 7 - 12																	
2003	**HIGHLANDERS**			**REDS**			**STORMERS**			**CHIEFS**			**SHARKS**			**CATS**		
Average forced missed tackles	2.83			2			1.82			2.6			1.89			1.5		
Average number of collisions	6.11			4.6			4.71			5.6			4.78			3.5		
Ratio of collisions vs passes	1.05			1			1.08			1			0.92			0.9		
Average positive velocity change/100	2.86			3.9			3.76			4.9			3.03			2.8		
2004	**HIGHLANDERS**			**REDS**			**STORMERS**			**CHIEFS**			**SHARKS**			**CATS**		
Average forced missed tackles	2.05	-27.6%		1.6	-20.5%		1.45	-20.3%		2.3	-13.8%		1.43	-24.3%		1.2	-16.3%	
Average number of collisions	5.95	-2.6%		3.7	-19.3%		3.95	-16.1%		5.2	-7.5%		3.86	-19.2%		4.3	22.1%	
Ratio of collisions vs passes	1.09	3.8%		0.9	-3.1%		0.93	-13.9%		0.9	-9.9%		0.82	-10.9%		0.8	-16.7%	
Average positive velocity change/100	4.61	61.4%		4	1.4%		4.99	32.6%		4.8	-1.1%		4.29	41.4%		4.5	59.3%	
2005	**HIGHLANDERS**			**REDS**			**STORMERS**			**CHIEFS**			**SHARKS**			**CATS**		
Average forced missed tackles	3.11	51.7%	9.9%	2.8	74.2%	38.5%	1.42	-2.1%	-22.0%	3.8	68.9%	45.6%	1.56	9.1%	-17.5%	1.9	51.2%	26.5%
Average number of collisions	6	0.8%	-1.8%	5.5	47.2%	18.7%	3.16	-20.0%	-32.9%	7.3	39.7%	29.2%	3.44	-10.9%	-28.0%	4	-7.2%	13.3%
Ratio of collisions vs passes	1.5	37.6%	42.9%	1.1	21.3%	17.5%	0.87	-6.5%	-19.4%	1.4	56.0%	40.6%	0.92	12.2%	0.0%	0.8	2.7%	-14.4%
Average positive velocity change/100	5.74	24.4%	100.9%	5.3	33.7%	35.6%	5.24	5.1%	39.4%	6	23.2%	21.8%	5.26	22.8%	73.6%	5.8	28.0%	103.9%

	HIGHLANDERS	REDS	STORMERS	CHIEFS	SHARKS	CATS
Position 2003	7	8	9	10	11	12
Position 2004	9	10	3	4	8	12
Position 2005	8	10	9	6	12	11
Position - Average	8	9	7	7	10	12
Class A changes 2003 - 2004	0	0	1	0	1	1
Class B changes 2003 - 2004	1	0	0	0	0	0
Class A changes 2004 - 2005	1	2	0	2	0	1
Class B changes 2004 - 2005	0	1	0	1	0	0
Class A changes 2003 - 2005	1	2	2	2	0	0
Class B changes 2003 - 2005	1	0	0	0	1	1
Total Class A changes	2	4	3	4	1	2
Total Class B changes	2	1	0	1	1	1
Total Changes	4	5	3	5	2	3

Table 8.16: Changes in collisions 2003 – 2005 between nations

CHANGES IN COLLISIONS 2003 - 2005 BETWEEN NATIONS									
2003		NZ			SA			AUS	
Average forced missed tackles	2.5			1.8			2.15		
Average number of collisions	5.92			4.3			5.08		
Ratio of collisions vs passes	1.23			1			1.06		
Average positive velocity change / 100	4.57			3.6			3.67		
2004		NZ			SA			AUS	
Average forced missed tackles	2.3	-8.0%		1.6	-10.9%		2.08	-3.4%	
Average number of collisions	5.71	-3.6%		4.1	-4.6%		4.77	-6.0%	
Ratio of collisions vs passes	1.05	-14.6%		0.9	-16.0%		1.02	-4.1%	
Average positive velocity change / 100	4.69	2.6%		4.9	34.2%		4.5	22.7%	
2005		NZ			SA			AUS	
Average forced missed tackles	3.69	60.2%	47.4%	2.2	41.4%	26.0%	3.3	58.8%	53.4%
Average number of collisions	6.91	21.0%	16.6%	4.4	7.7%	2.7%	6.48	35.7%	27.6%
Ratio of collisions vs passes	1.61	53.4%	31.0%	1.2	31.3%	10.3%	1.26	23.9%	18.9%
Average positive velocity change / 100	6.58	40.3%	43.9%	5.8	18.7%	59.2%	6.28	39.6%	71.3%
		NZ			SA			Aus	
Class A changes from 2003 - 2004		0			1			0	
Class B changes from 2003 - 2004		0			0			0	
Class A changes from 2004 - 2005		2			2			3	
Class B changes from 2004 - 2005		1			0			0	
Class A changes from 2003 - 2005		3			1			2	
Class B changes from 2003 - 2005		0			0			1	
Total Class A changes		5			4			1	
Total Class B changes		1			0			1	
Total Changes		6			4			2	

The major reason for the South African team's higher value regarding change in regard to the four key performance factors is most definitely due to the Bulls markedly higher values attained during the competitions participated in during the 2004 and 2005 seasons. This is also shown by the Bulls high log finishing positions in 2004 and 2005. If the Bulls team performed at the same level as the other South African teams, the total changes would most definitely be significantly lower. It becomes evident that those teams that endeavoured to improve their collision statistics in the four key performance areas, were more successful than those teams that did not.

CHAPTER 9

RECOMMENDATIONS

Although there were numerous observations made, recommendations will be isolated to those factors where dominant collisions affecting the scoring of a try will be discussed.

9.1 INTERPRETATION OF THE DATA

In rugby, there is a name for teams that fail to execute the fundamentals: losers. And there is nothing more fundamental in rugby than ball carrying collisions and non ball carrying collisions (rucking and tackling). Incredible moves, and exceptional incisive runs are fun to watch and can make the difference in a game or two over the course of a season, but they ultimately mean little if the team is failing at the basics. A superb athlete who has been well coached and has the aggressive desire to make an impact on the game will consistently make solid tackles and ball carrying collisions – the kind that make the team's plays work and force those of his opponents to fail.

The ultimate collision athlete has to have the work ethic and technical skills of a consummate professional along with the heart of a warrior, the ability to read the play of the opposition, and the ability to close with ferocious speed on a ball carrier or defender. Looming in the runner's or defender's path with his head up and shoulders squared, driving through the ball carrier or defender with an incredibly beautiful, fluid motion that results in the defender being smashed in the ensuing collision and brushed away at will, the ball being dislodged from the ball carriers grasp or the ball carrier lying flat on his back and being driven into the ground.

In order to begin the necessary recommendations a broad overview is important to know from which facet of play the tries that were evaluated were scored from. This sets the beginning point of the play as well as the necessary discussions.

Table 9.1: Distribution of tries scored as a percentage – 2003

DISTRIBUTION OF TRIES SCORED AS A PERCENTAGE - 2003								
Log Position	Team	Restarts	Left Scrum	Middle Scrum	Right Scrum	Left Lineout	Right Lineout	T/O or Pen
1	CRUSADERS	0%	10%	6%	10%	13%	13%	48%
2	BLUES	6%	4%	6%	9%	18%	9%	48%
3	HURRICANES	12%	6%	3%	9%	29%	6%	35%
4	ACT	7%	13%	7%	0%	27%	7%	39%
5	NSW	4%	10%	0%	4%	40%	8%	34%
6	BULLS	4%	4%	0%	13%	14%	17%	48%
7	HIGHLANDERS	11%	11%	6%	0%	28%	11%	33%
8	REDS	7%	7%	0%	2%	40%	13%	31%
9	STORMERS	0%	0%	12%	11%	0%	12%	65%
10	CHIEFS	5%	10%	5%	0%	19%	9%	52%
11	SHARKS	11%	11%	17%	11%	0%	6%	44%
12	CATS	0%	6%	0%	0%	7%	0%	87%

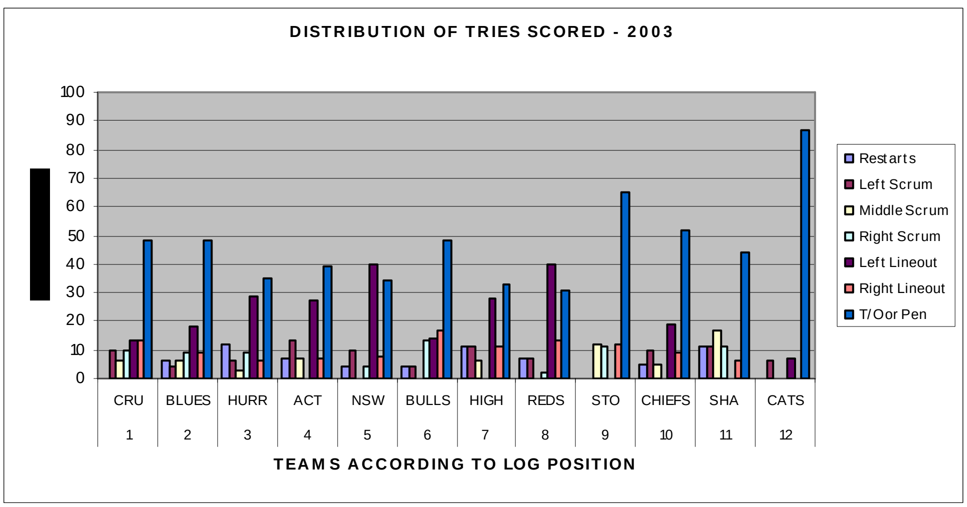


Figure 9.1: Distribution of tries scored – 2003

As is evident from Table 9.1 and Figure 9.1, it indicates that most tries scored during the 2003 Super 12 season were in fact scored from turnover possession. The second most tries from left hand lineouts and third most tries from left hand scrums.

Table 9.2: Distribution of tries scored as a percentage – 2004

DISTRIBUTION OF TRIES SCORED AS A PERCENTAGE - 2004								
LOG POSITION	TEAM	RESTARTS	LEFT SCRUM	MIDDLE SCRUM	RIGHT SCRUM	LEFT LINEOUT	RIGHT LINEOUT	T/O or PEN
1	ACT	0%	13%	0%	6%	26%	8%	47%
2	CRUSADERS	5%	14%	4%	0%	23%	15%	39%
3	STORMERS	0%	5%	0%	0%	36%	14%	45%
4	CHIEFS	0%	40%	0%	0%	20%	7%	33%
5	BLUES	4%	21%	1%	8%	33%	8%	25%
6	BULLS	0%	3%	2%	8%	16%	21%	50%
7	NSW	0%	4%	1%	4%	26%	21%	44%
8	SHARKS	0%	9%	7%	0%	29%	7%	48%
9	HIGHLANDERS	5%	0%	0%	16%	21%	5%	53%
10	REDS	0%	7%	1%	6%	33%	9%	44%
11	HURRICANES	0%	7%	1%	0%	27%	4%	61%
12	CATS	8%	15%	0%	3%	8%	2%	64%

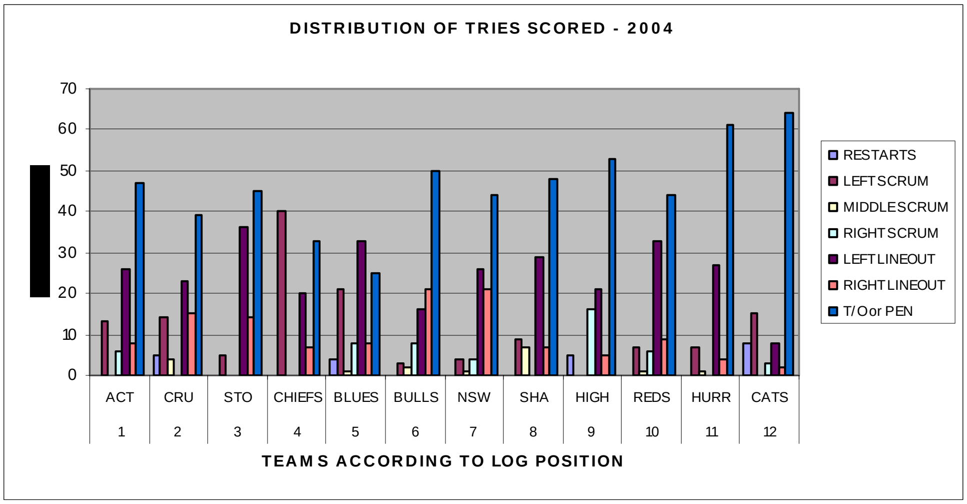


Figure 9.2: Distribution of tries scored – 2004

As is evident from Table 9.2 and Figure 9.2, it indicates that most tries scored during the 2004 Super 12 season were in fact scored from turnover possession. The second most tries from left hand lineouts and third most tries from left hand scrums.

Table 9.3: Distribution of tries scored as a percentage – 2005

DISTRIBUTION OF TRIES SCORED AS A PERCENTAGE - 2005								
LOG POSITION	TEAM	RESTARTS	LEFT SCRUM	MIDDLE SCRUM	RIGHT SCRUM	LEFT LINEOUT	RIGHT LINEOUT	T/O or PEN
1	CRUSADERS	3%	5%	0%	4%	18%	8%	62%
2	NSW	0%	10%	1%	6%	29%	6%	48%
3	BULLS	5%	7%	8%	0%	8%	4%	68%
4	HURRICANES	0%	5%	1%	4%	36%	9%	45%
5	ACT	0%	7%	0%	4%	63%	15%	11%
6	CHIEFS	0%	11%	0%	0%	26%	10%	53%
7	BLUES	0%	15%	0%	4%	15%	8%	58%
8	HIGHLANDERS	0%	6%	5%	0%	28%	0%	61%
9	STORMERS	0%	26%	5%	0%	16%	16%	37%
10	REDS	0%	16%	0%	15%	23%	15%	31%
11	CATS	0%	14%	0%	0%	14%	21%	51%
12	SHARKS	0%	7%	6%	0%	25%	6%	56%

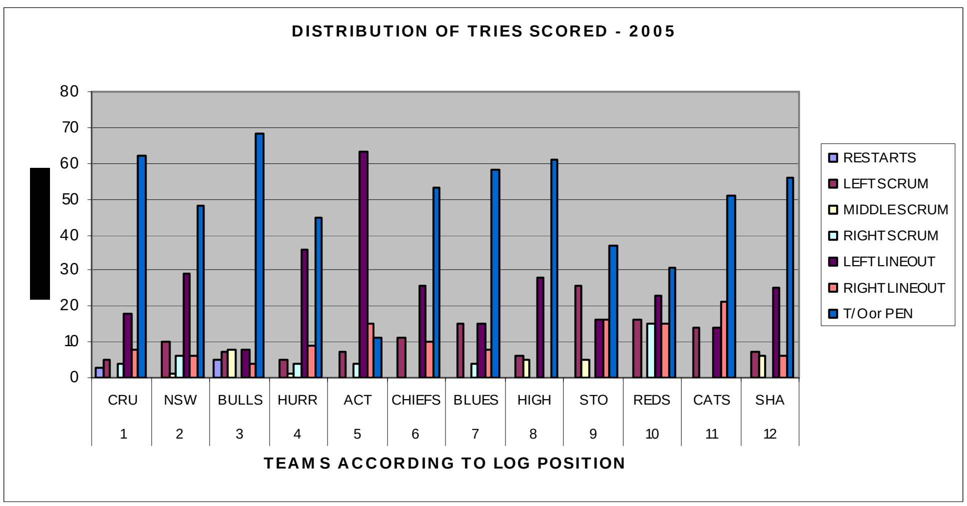


Figure 9.3: Distribution of tries scored - 2005

As is evident from Table 9.3 and Figure 9.3, it indicates that most tries scored during the 2005 Super 12 season were in fact scored from turnover possession. The second most tries from left hand lineouts and third most tries from left hand scrums.

9.2 PHYSICS versus ABILITY: WHAT IS THE LINK?

Physical law places absolute limits on what players can and can't do. Physics can be used to understand why the tried-and-true, basic advice that coaches give to their players about technique works so well in rugby. It is possible to use physics to reveal just how incredibly talented rugby union players have to be to do what they do, and in such spectacular fashion. But when one gets into the detailed differences between the running ability of two players, for example, or try to analyse why a poorer team beats a good one, it becomes increasingly difficult to make definitive statements. Part of the problem is that human beings are extremely complicated biomechanical machines.

The attempt to make a detailed analysis of how humans move, especially with regard to sports activities is the area of kinesiology. One of the main goals of kinesiology is to develop guidelines for what is and isn't good technique in a given sports activity. What becomes increasingly obvious is that although trends can be identified when evaluating performance, the real art is the coach's ability to make the tough calls on players based on the feedback from player performance and then the "X" factor that the coach needs to posses in order to create a top quality team.

9.3 WHERE COACHING COMES IN: THE EFFECTIVE USE OF CENTRE OF MASS AND TORQUE

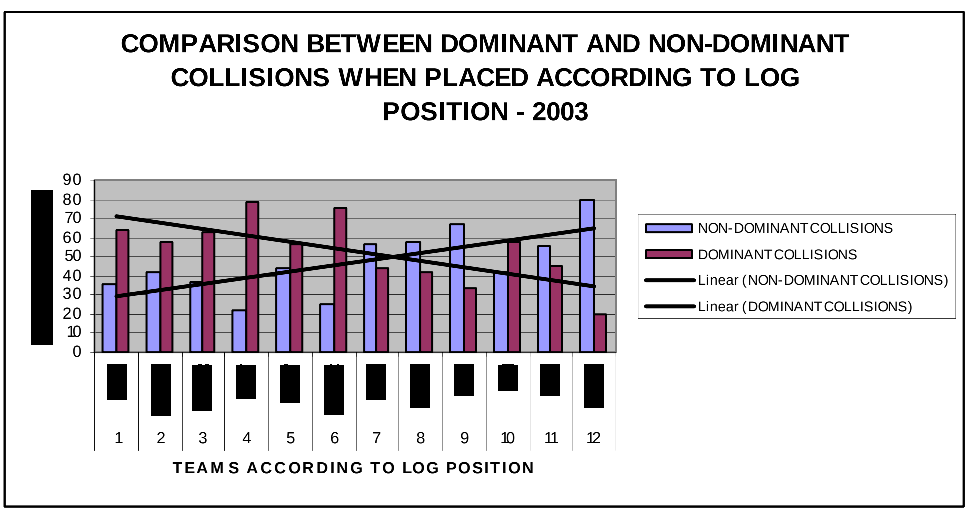
As has been shown throughout the study, the physics ideas presented are as applicable to ricocheting billiard balls as they are to colliding ball carriers and defenders. But it is obvious that there is more to a rugby match than inanimate masses colliding with each other. The question arises as to what is it about the fundamentals of ball carriers and defenders colliding with each other that can be taught by coaches?

The following statistics were obtained and give an indication of the importance of how and where the collision takes place, and the impact it has on the log position eventually obtained.

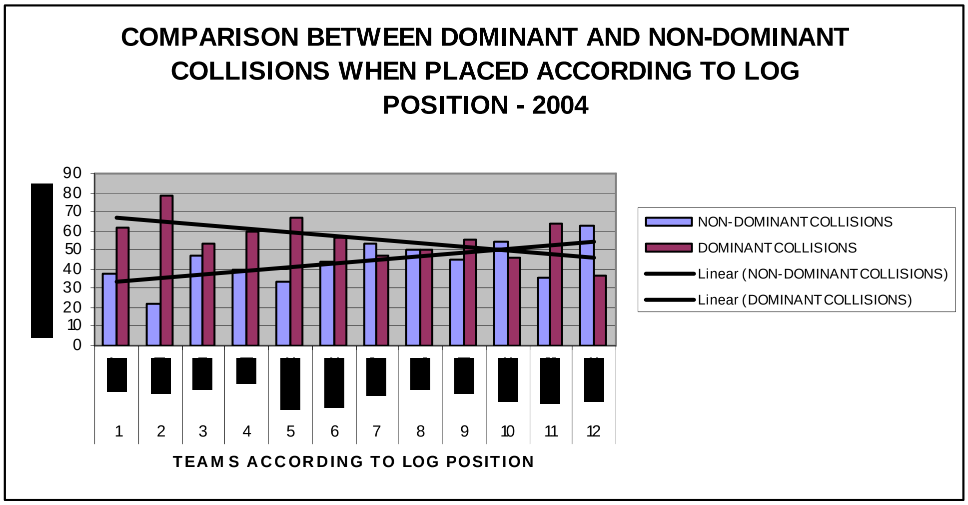
Table 9.4: Comparison between dominant and non-dominant collisions when placed according to log positions

COMPARISON BETWEEN DOMINANT AND NON-DOMINANT COLLISIONS WHEN PLACED ACCORDING TO LOG POSITION												
LOG POSITION - 2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLU	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHI	SHA	CATS
NON-DOMINANT COLLISIONS	36%	42%	37%	22%	44%	25%	56%	58%	67%	42%	55%	80%
DOMINANT COLLISIONS	64%	58%	63%	78%	56%	75%	44%	42%	33%	58%	45%	20%
LOG POSITION - 2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHI	BLU	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
NON-DOMINANT COLLISIONS	38%	22%	47%	40%	33%	44%	53%	50%	45%	54%	36%	63%
DOMINANT COLLISIONS	62%	78%	53%	60%	67%	56%	47%	50%	55%	46%	64%	37%
LOG POSITION - 2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHI	BLU	HIGH	STO	REDS	CATS	SHA
NON-DOMINANT COLLISIONS	29%	25%	30%	35%	45%	35%	55%	54%	47%	30%	73%	58%
DOMINANT COLLISIONS	71%	75%	70%	65%	55%	65%	45%	46%	53%	70%	27%	42%

(a)



(b)



(c)

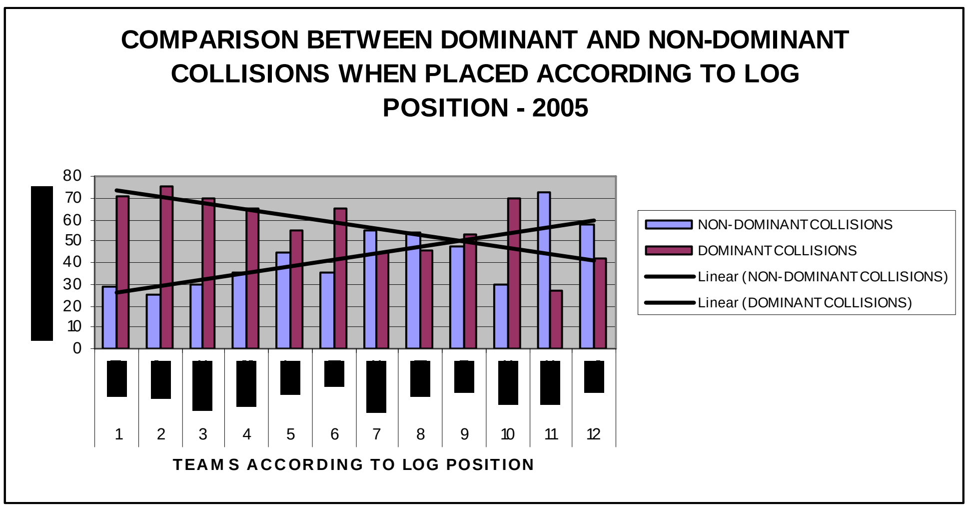
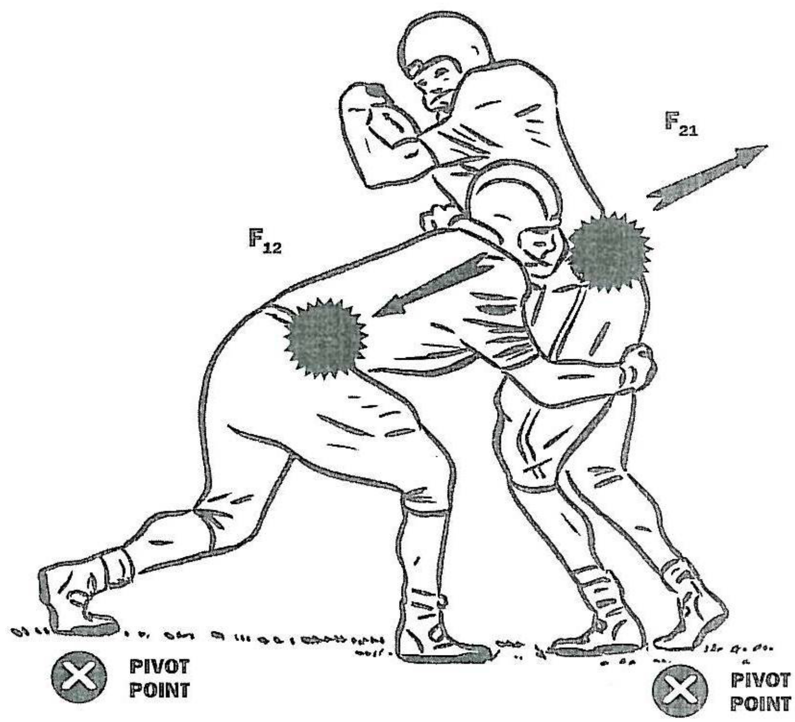


Figure 9.4 (a,b,c): Comparison between dominant and non-dominant collisions when placed according to log position 2003, 2004 and 2005

As is evident from Table 9.4 and Figures 9.4 (a,b,c), it is clear that those teams that had a higher percentage of dominant collisions when compared to non-dominant collision were more likely to finish higher on the respective season log ad thus be more successful. These statistics clearly show that teams that are more successful are better able to dominate collisions and have a higher percentage of dominant collisions when compared to non-dominant collisions. These statistics were obtained from the appropriate statistics sheets and are described in chapter 7 under the heading of key factors present at the in contact situation as the collision takes place. A discussion of possible reasons why and how this can be achieved follows. The further question as to why when executed correctly, can small, quick defensive players sometimes demolish big forwards that are hurtling down on them? The first most basic instruction that coaches should give players about tackling an opponent and when driving into a defensive opponent should be that they: " Keep their feet apart, stay low with their head up, and to drive upward and through the opposing player." In order to understand why this technique is so effective, the following physics ideas need to be explored: the centre of mass and torque. Torque is the rotational equivalent of force. In the same way that force causes a mass to accelerate along a straight line, torque causes objects to rotate about a pivot line, sometimes called the axis of rotation. The bigger the torque, the more effective it is at causing the object to which it is applied to rotate about its pivot line (Beer & Johnston, 1990; Young, 1992; Van Staden *et al*., 1992; Hamill & Knutzen, 1995; Kreighbaum & Barthels, 1996; McAleer, 1998; Brister, 2000; McKenzie *et al*., 2000; Tripi, 2001; Unknown author, 2003; Gay, 2004).

Torque by itself doesn't tell one much about tackling or driving into a defender unless it is combined with an understanding of a player's center of mass. An object's center of mass is essentially the point through which one would consider the pull of gravity on that object to act. This is why the center of mass is also referred to as the centre of gravity. Most people have a basic concept of where the center of mass of an object lies – roughly at the objects center. A player's center of mass is roughly just below his rib cage, on his vertical center line.

When a player assumes a wide stance and crouches down to make a hit, his center of mass lowers (but remains in his torso area). Therefore, when tackling or driving into an opponent, the reason to stay low and drive upward through the opposing player is so that the player can control his motion by exerting far more torque on him than he does on the opposition player. As shown by Newton's Third Law, the player exerts the same force on the defender or ball carrier as he does on himself, however by using his knowledge of centers of mass, he can completely dominate him in terms of torque. This gives the ball carrier the biomechanical advantage at the collision site and this enables the player to dominate the collision and thus be more successful when running at the opposition (Beer & Johnston, 1990; Young, 1992; Van Staden *et al.*, 1992; Hamill & Knutzen, 1995; Kreighbaum & Barthels, 1996; McAleer, 1998; Brister, 2000; McKenzie *et al.*, 2000; Tripi, 2001; Unknown author, 2003; Gay, 2004).



(Adapted from Gay, 2004)

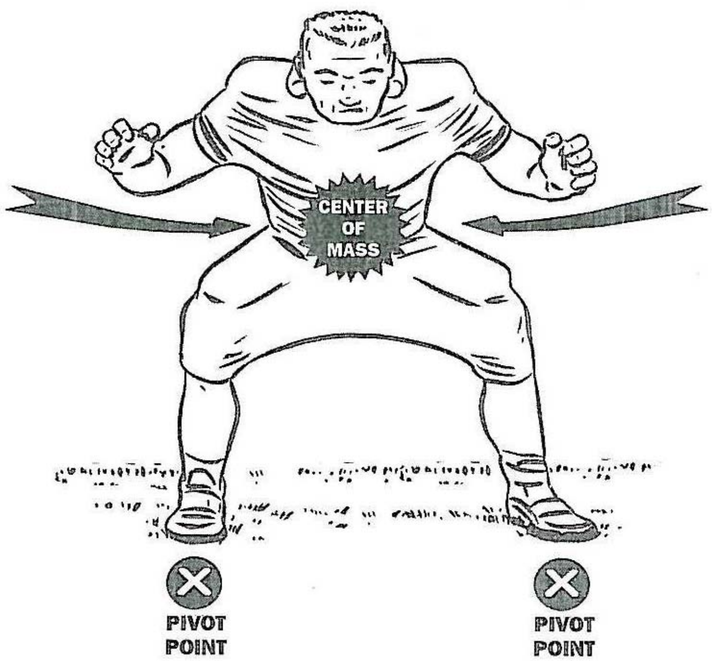
Figure 9.5: Player on the left lowers his center of mass and drives up and through the ball carrier at the right. The two player's centers of gravity are indicated with solid black bursts. Pivot points occur where the player's feet contact the ground, indicated with an X.

When observing Figure 9.5, the two players meeting in the collision initially exert equal magnitudes of force on each other as soon as they make contact. The force the defender exerts runs roughly along the line of his body and up through the ball carrier's torso. The ball carrier exerts a force equal in magnitude but opposed in direction ($F_{12} = -F_{21}$). The equal forces that they exert on each other, however, do not result in equal torques.

The ball carrier exerts a force on the defender that extends along the line connecting the defenders centre of mass and his effective pivot point – the point of contact between his back foot and the ground. The defender is thus very stable under the force from the ball carrier. On the other hand, he has a large lever arm – a large amount of leverage – with the force that he exerts on the ball carrier, who rotates rapidly about his point of contact with the ground as a result of this torque, becoming unstable under the unexpected rotational motion. At the least, the defender will stop the ball carrier, effectively halting his forward motion. Ideally the ball carrier will be completely bowled over and lose the ball in the process. In this kind of hit, the coach's focus on "keeping the head up" doesn't affect the amount of torque delivered directly, but it does help the defender to follow through with the motion that delivers the torque. As for how far apart to keep one's feet as the player sets himself up to make the tackle, a good rule of thumb is to plant them slightly wider than shoulder width (Beer & Johnston, 1990; Young, 1992; Van Staden *et al.*, 1992; Hamill & Knutzen, 1995; Kreighbaum & Barthels, 1996; McAleer, 1998; Brister, 2000; McKenzie *et al.*, 2000; Tripi, 2001; Unknown author, 2003; Gay, 2004).

This again relates to stability, but now the focus is on stability in the lateral, side-to-side sense. When looking at Figure 9.1, anytime a ball carrier and a defender meet in a collision and it does not take place in a straight plane, i.e., not head on, the player's body will experience lateral forces upon contact (Beer & Johnston, 1990; Young, 1992; Van Staden *et al.*, 1992; Hamill & Knutzen, 1995; Kreighbaum & Barthels, 1996; McAleer, 1998; Brister, 2000; McKenzie *et al.*, 2000; Tripi, 2001; Unknown author, 2003; Gay, 2004).

The reason why this information is relevant is the fact that these physics principles are as applicable to the defender as they are to the ball carrier when he enters the collision site and is forced to deal with a defender looking to tackle him aggressively backwards. It is thus important to be aware of these aspects and to apply these principles to attacking play.



(Adapted from Gay, 2004)

Figure 9.6: Lateral forces are less effective at destabilising a player whose stance is low to the ground. The player's feet act as pivot points for his body – and come into play depending on the direction of the force applied by the opposing player. His centre of mass is indicated.

As is evident from Figure 9.6, if the player's feet were close together at this time, there would be significant leverage for these lateral forces about the point of contact between the feet and the ground. With the feet spread, however, the pivotal point is whichever foot is opposite to the point of contact between the lateral force and the body. Because the body is low, below this point of contact the leverage for the lateral torque is small, and the tendency for your body to rotate off the tackle is minimised. Again, the crucial point here is that the tackler must keep his centre of mass as low as possible. The physics of driving into the opposition and tackling must be seen as the basics of dominating collisions. All the complex science discussed wont do a team much good if the players don't execute efficiently (Gay, 2004).

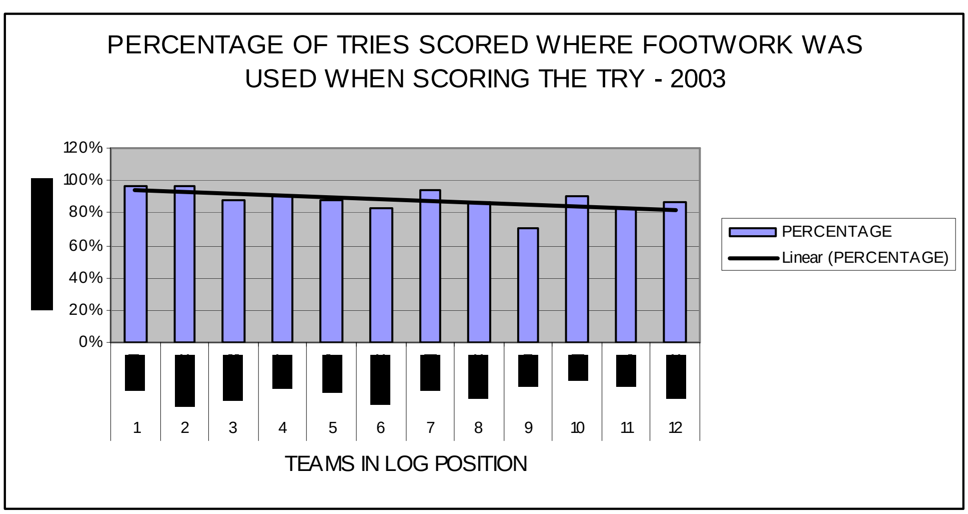
9.4 SPEED, AGILITY, QUICKNESS AND THE ABILITY TO BEAT THE DEFENDER WITH FOOTWORK

On of the most effective means of wrong-footing a defender and making the ball carrier's job of dominating the collision site is the use of effective, dynamic footwork before the collision takes place. When this is viewed in respect to the statistics obtained from the various Super 12 competitions the following comes to the fore.

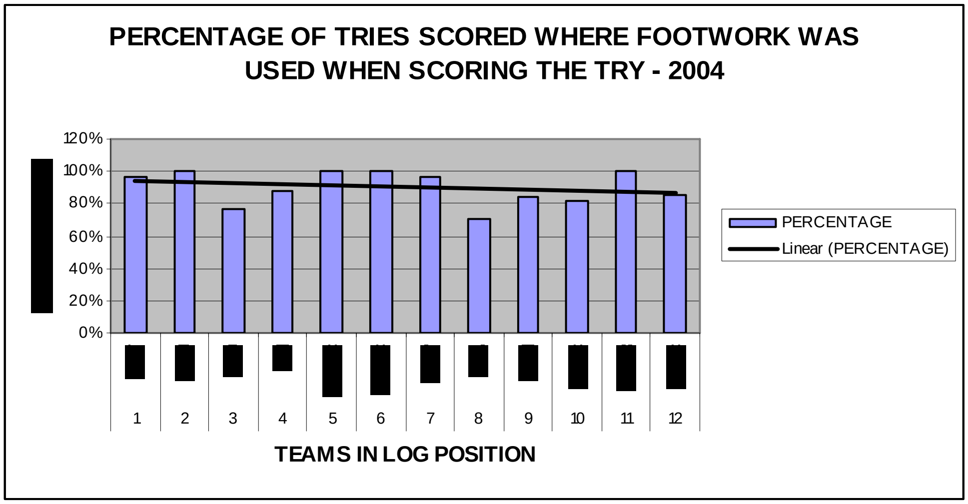
Table 9.5: Percentage of tries where footwork was used when scoring the try

PERCENTAGE OF TRIES SCORED WHERE FOOTWORK WAS USED WHEN SCORING THE TRY												
2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLUES	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHI	SHA	CATS
PERCENTAGE	97%	97%	88%	90%	88%	83%	94%	87%	71%	90%	83%	87%
2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHI	BLUES	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
PERCENTAGE	97%	100%	77%	88%	100%	100%	96%	71%	84%	82%	100%	85%
2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHI	BLUES	HIGH	STO	REDS	CATS	SHA
PERCENTAGE	97%	97%	84%	100%	100%	90%	79%	89%	89%	77%	71%	69%

(a)



(b)



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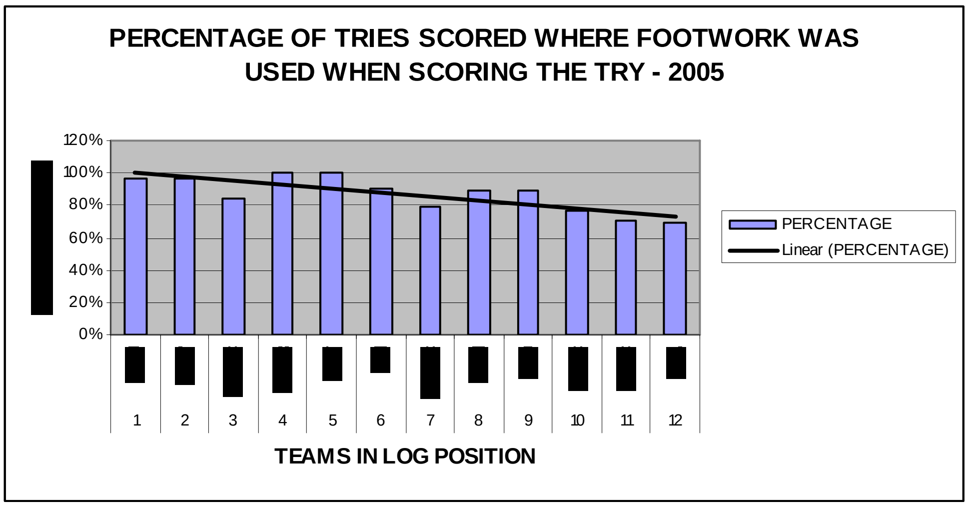
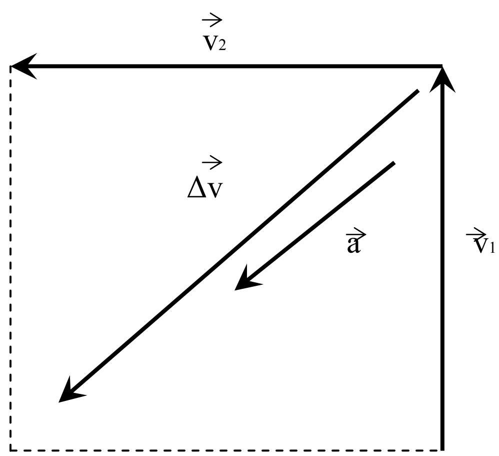


Figure 9.7 (a,b,c): Percentage of tries scored where footwork was used when scoring the try

As is evident from the above data Table 9.5 and Figures 9.7 (a,b,c) it becomes evident that the teams that make use of a higher percentage of footwork before the collision takes place when tries were scored finished higher on the respective log than those that did not.

The reason for this in fact occurring can be explained in the following explanations. Footwork can be defined as a rapid change of course direction, possibly involving a change in speed, possibly repeated several times in quick succession. Naturally both defenders and ball carriers will make use of footwork respective to their role; however the ability to be outstanding in this skill is a much valued characteristic. As a rugby physicist, one knows that you are dealing with changes of speed and direction in short amounts of time: big accelerations. If one looks at the following example, this skill and its ability to aid in a successful dominant collision becomes evident. Consider the common scenario of an attacking backline player running hard at a lone defender attempting to wrong foot him and hopefully leave the defender in his tracks. This ball carrier's velocity vector through the line is roughly straight ahead, with a magnitude (length) of 18 feet per second (V_1) → (see Figure 9.7) (Gay, 2004).



$\vec{a}$ = 4g's

(Adapted from Gay, 2004)

Figure 9.8: Velocity vectors before (V_1→) and after (V_2→) the player moves, connected by the change in his velocity (ΔV→), yield his acceleration (a→): 4g's

The ball carrier plants his right foot hard just as a head-on collision with the defender seems to be inevitable, and, literally in the blink of an eye, he is now moving at 18 feet per second at right angles to his initial velocity (V_2→). The defender's reaction to this footwork is typical of defensive players who encounter such fleet footed ball carriers in the open field: they are left standing and cannot adjust to even come close to the ball carrier let alone tackle him. If the tackle is made the defender is in no way able to execute a dominant tackle of any sort.

Using vectors and Pythagorean Theorem, it can be shown that the acceleration vector ($a\rightarrow$) related to ($V_2\rightarrow$) and ($V_1\rightarrow$) has a magnitude of 127 feet per second squared. Using Newton's Second Law, it can also be calculated what the force is of the ball carrier has to exert on the ground to produce an acceleration of this magnitude: 2,300 pounds. Since all this force is essentially acting through his right knee and ankle as he makes the cut, one can appreciate where ankle and knee injuries come from.

Notice that this amount of force gives the ball carrier an acceleration of about 4 g's. If the ball carrier could continue accelerating at this rate for 10 seconds, he would be moving faster than the speed of sound (Gay, 2004).

9.5 THE ABILITY TO RUN OVER THE DEFENDER

There are two specific ways that a ball carrier can dominate the collision and totally demolish the defender:

1. a full-on defender beating collision where the defender is blown off and merely temporarily halts the ball carriers forward momentum, with the ball carrier continuing his forward motion: and
2. repeated execution of collisions that in effect soften up the opposition before the final knock-out blow is issued.

9.5.1 A full-on defender beating collision

This collision is one where the ball carrier is at a total advantage in terms of:

1. attacking from quick ball,
2. being at full speed when running onto the ball,
3. the level of effective footwork ahead of the collision so that the ball carrier dominates the collision site;

4. the defender is flat footed;
5. the defender is forced to tackle making use of his weaker shoulder,
6. the defender has been manipulated into over tracking by the probe used by the attacking backline and the ball carrier hits the line using the effective running line,
7. the ball carrier enters the collision site with his full mass moving through the line of application of the defender;
8. the ball carrier is physically bigger and more powerful than the defender; and
9. the ball carrier has a player/s leached to him thus doubling the mass of the ball carrier into the collision.

Although only one of these factors is required to create this type of collision, if all these factors are present it stands to reason that the execution becomes easier.

9.5.1.1 Attacking from quick ball or slow ball

This aspect of the collision is crucial. The ball carrier as well as his team must dominate the collision site, i.e., must only send the players in if they know they can dominate the situation. This is done by distinguishing between slow and quick ball. This entails decision-making and communication from the player in the flyhalf position. If it is slow ball, the defensive line will be organised and they will be charged up to rush up hard onto the ball carrier. If the ball is passed backwards from slow ball, the ball carrier will be caught behind the advantage line and he will be attempting to run hard at the defensive line but will however be coming from a standing start. In this situation, it becomes obvious that the ball carrying team is not dominating the situation. In order to bring the advantage back to the attacking team, this slow ball has to be recreated into quick recycled possession. This can be done by either setting up a mini-maul, or setting up a pick and drive situation. If this is done effectively and the ball can be recycled before the defenders can fold extra defenders on the openside of the ruck, then the advantage is back with the attacking team. The reason this occurs is because the defenders that are folding towards the openside are not in an optimal body position to be able to chase the press or to execute a dominant tackle. In effect, the team that can run more often at the defenders from quick recycled possession will inadvertently dominate the collision site more often.

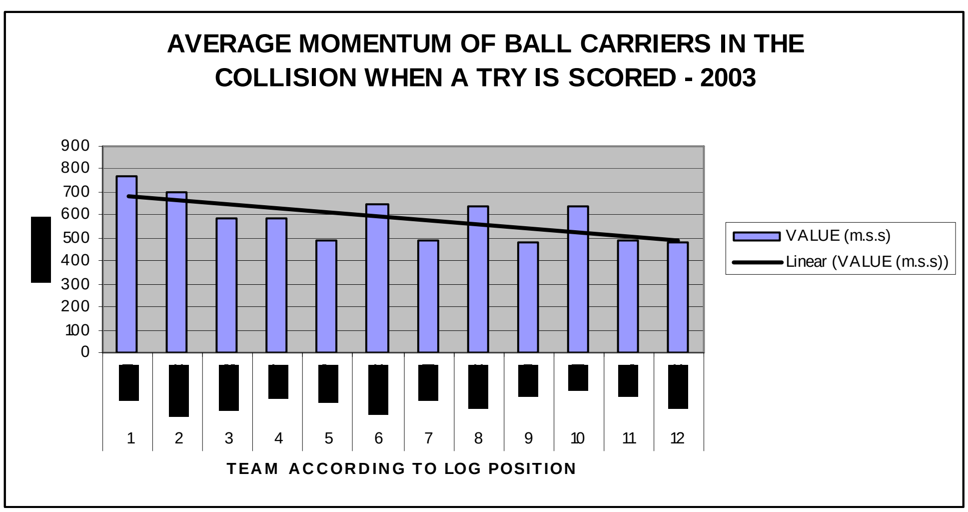
9.5.1.2 The ball carrier's ability to hit the collision line at maximum speed when running onto the ball

After evaluation of the following data the importance of a player being able to hit the tackle line with force was clearly highlighted.

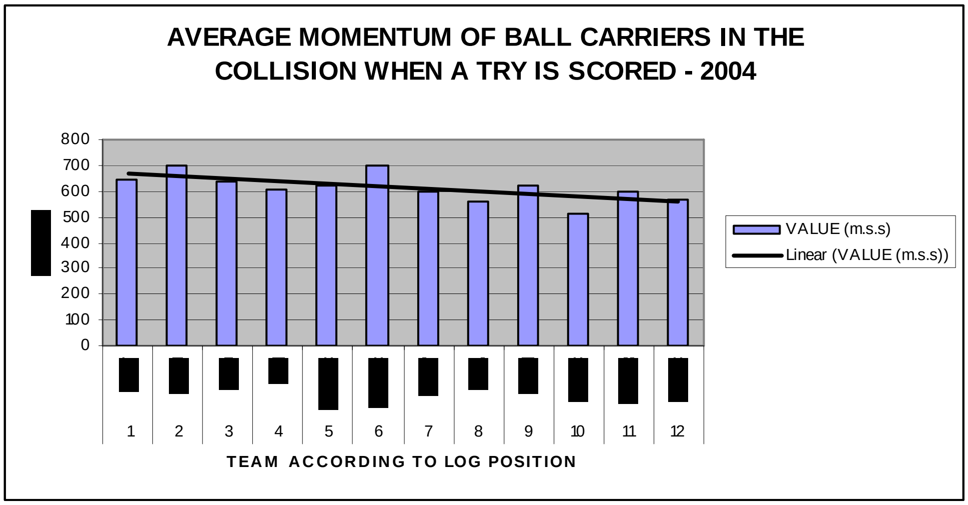
Table 9.6: Average momentum of ball carriers in the collision when a try is scored

AVERAGE MOMENTUM OF BALL CARRIERS IN THE COLLISION WHEN A TRY IS SCORED												
2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLUES	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHI	SHA	CATS
VALUE (m.s.s)	771.13	703.01	588.07	582.18	489.35	642.77	488.32	636.27	480.39	642.01	493.34	481.37
2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHI	BLUES	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
VALUE (m.s.s)	646.6	700.4	635.61	604.92	624.08	700.68	595.25	561.43	623.89	508.95	597.87	565.66
2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHI	BLUES	HIGH	STO	REDS	CATS	SHA
VALUE (m.s.s)	1003.41	895.4	865.18	881.00	828.37	812.78	797.52	733.58	701.72	687.91	793.63	742.44

(a)



(b)



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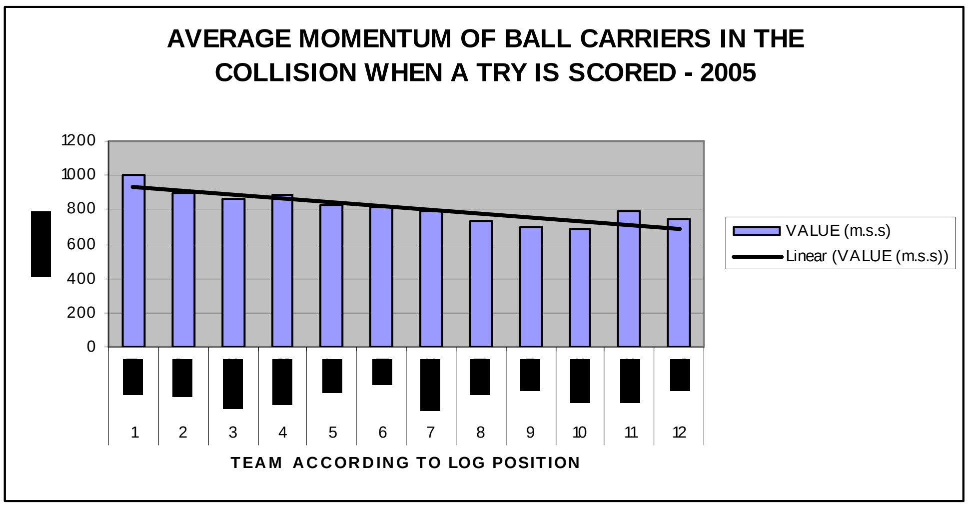


Figure 9.9 (a,b,c): Average momentum of ball carriers in the collision when a try is scored – 2003, 2004 and 2005

These statistics from Table 9.6 and Figure 9.9 (a,b,c) clearly show the importance of players being able to run hard at the opposition and dominate the collision site. Teams that were most successful have a markedly higher value when compared with those teams placed lower on the respective logs.

The following factors could be reasons why this in fact did occur. In order for the ball carrier to be able to hit the collision line at maximum speed, the timing of his approach and his ability to run off the player who is feeding him with the possession is crucial. If there is any deceleration on the ball carriers part due to either a poor pass, poor realignment by the ball carrier off the passer, or poor judgment on the part of the ball carrier concerning the target set for the collision, the ball carrier will not be able to really "throw" himself into the collision. With defensive lines, organization and field coverage being as effective and dominating as they are, this form of full on collision attack has become necessary. It is no longer possible to merely fling the ball around the park in the hope that an opportunity will pop up. It has become increasingly necessary for attacking teams to earn their yardage that is gained from this form of attacking ploy. Attacking teams will therefore aim to bring their best ball carriers into play as often as possible. This means that their play is structured in such a way that:

1. the best passes are used to get the ball into the ball carrier's hands,
2. the best carriers carry the ball into the collisions,
3. the best running off the ball supporters run off the ball carrier at the collision site in anticipation of a quality off-load,
4. the best cleaners are put onto the ball carriers behind so that effective clean can be executed thus resulting in quick ball being recycled; and finally that
5. the best distributing backs are aligned off the recycled possession so that advantage can be taken of the quality attacking ball that has been created.

All effort must be placed on the fact that the ball carrier must never receive the ball while being stationary thus forcing him to enter the collision site from a standing start. It thus stands to reason that the teams that are able to create such a situation the most often has a greater chance of success in attempting to increase their execution of full-on defender beating collisions.

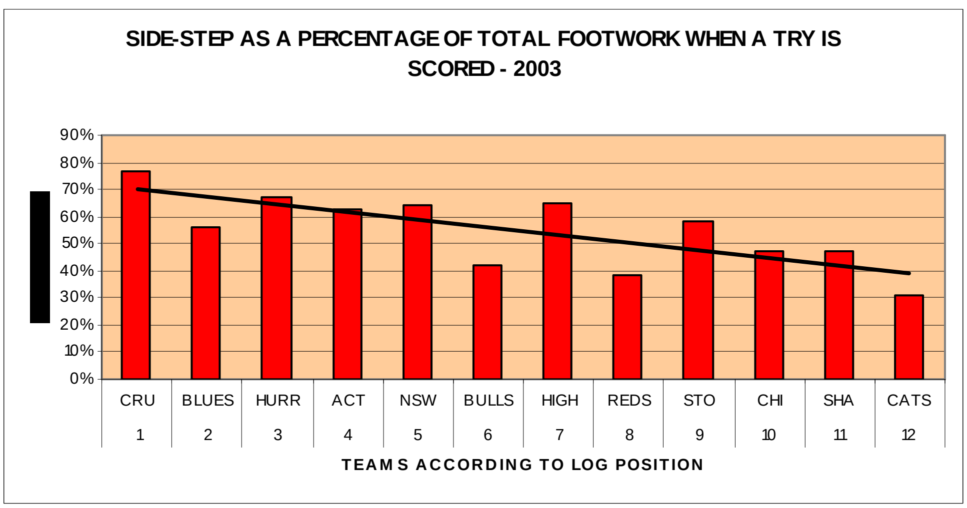
9.5.1.3 The level of effective footwork ahead of the collision so that the ball carrier dominates the collision site

When evaluating the following statistics the importance of effective footwork and specifically the side-step before the collision came to the fore.

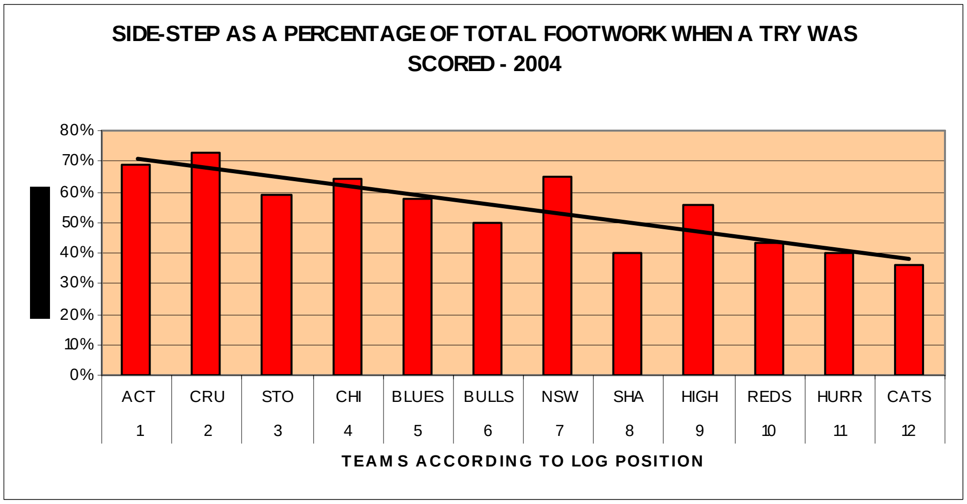
Table 9.7: Side-step as a percentage of total footwork when a try is scored

SIDE-STEP AS A PERCENTAGE OF TOTAL FOOTWORK WHEN A TRY WAS SCORED												
2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLUES	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHI	SHA	CATS
PERCENTAGE	77%	56%	67%	63%	64%	42%	65%	38%	58%	47%	47%	31%
2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHI	BLUES	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
PERCENTAGE	69%	73%	59%	64%	58%	50%	65%	40%	56%	43%	40%	36%
2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHI	BLUES	HIGH	STO	REDS	CATS	SHA
PERCENTAGE	74%	67%	48%	77%	63%	61%	43%	44%	47%	50%	40%	36%

(a)



(b)



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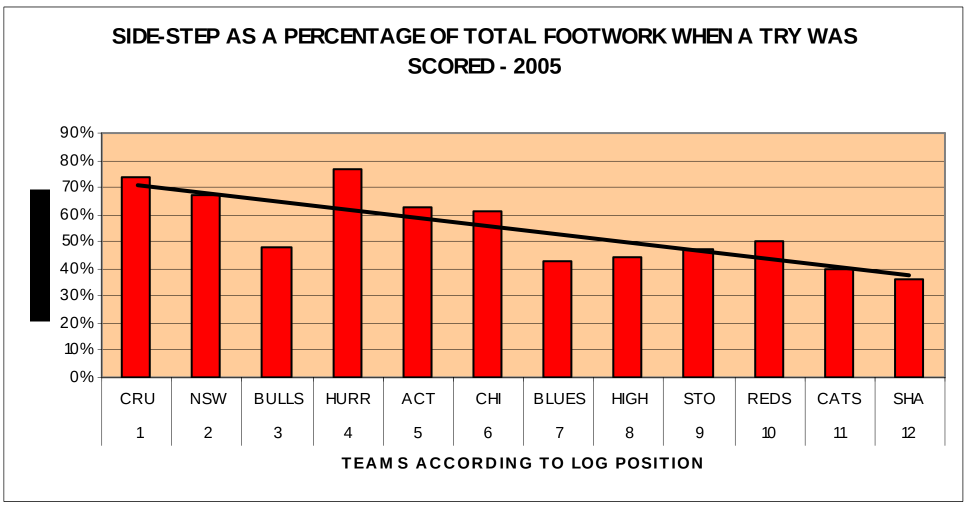


Figure 9.10 (a,b,c): Side-step as a percentage of total footwork when a try was scored – 2003, 2004 and 2005

The data from Table 9.7 and Figure 9.10 (a,b,c) clearly indicates that teams that made clear use of the relevant footwork i.e., the side-step, were more likely to execute a successful strike on the opposition defender and more importantly dominate the collision and thus aid their team to be more successful in their respective competitions. The teams that executed a higher percentage of side-step footwork were more successful in all three Super 12 competitions. As mentioned earlier it is crucial that the ball carrier dominates the collision area even before the collision takes place. This can be done by the ball carrier making use of effective footwork while approaching the collision site. The ball carrier thus attempts to off-foot the defender by destabilizing him thus allowing the ball carrier to run at maximum speed at a destabilized defender. This results in the ball carrier hitting the defender with maximum mass and speed, and the defender being stationary and not being able to execute a dominant tackle due to being wrong footed and thus not being able to take maximum mass intro the tackle. It is vital that while effective footwork can aid in the execution of a ball carrying collision, it must never take place at the cost of taking maximum speed into the collision. Often fleet footed players side-step or “triple” but often they move more sideways than what they move forwards. In effect, if a ball carrier has to choose between footwork and maximum speed, maximum speed must never be compromised.

9.5.1.4 Manipulation of the defender so that he is flat footed

In a rugby context, any time that a player is moving, he will almost always be able to dominate the situation, whether it be defending or carrying a ball into a collision. As mentioned earlier, if a ball carrier can run hard at a defender who is flat footed, the ball carrier will most definitely be more likely to dominate the collision. Apart from the fact of the velocity advantage, any slight directional change at the last minute that does not negatively impact on the velocity of the ball carrier will allow the ball carrier to either attack the weaker shoulder of the defender, or destabilize the defender in such a fashion that the defender is not able to apply his maximum mass into the tackle. The body positioning of the flat footed defender also plays a part in the ability of the defender to execute an effective tackle. If the flat footed defender’s center of gravity is not in front of their body, the defender will be inefficient in applying his mass and power into the tackle. If the defender’s center of gravity is behind his body (i.e., sitting on a chair defensive position), the defender will most definitely be in defensive trouble. A key component of this situation is to create situations where when a ball carrier runs hard at a defender that the defender’s centre of gravity is behind him thus making the defender unstable and thus the collision for the ball carrier more effective. Alternatively, defenders must concentrate on keeping their centre of gravity in front of their body so that they can attempt to make an effective tackle otherwise the physics of the situation will result in the downfall of the defender.

9.5.1.5 The defender is forced to tackle making use of his weaker shoulder

The premise used is that most of the rugby playing population are predominantly right handed. This would result in that if the ball carriers were executing their play from the left hand side of the field, that the defenders would be forced to make the defensive tackle making use of their left (i.e., weaker) shoulder.

Table 9.8: Distribution of tries scored as a percentage: 2003 - scrums

DISTRIBUTION OF TRIES SCORED AS A PERCENTAGE: 2003 - SCRUMS				
Log Position	Team	Left Scrum	Middle Scrum	Right Scrum
1	CRUSADERS	10%	6%	10%
2	BLUES	4%	6%	9%
3	HURRICANES	6%	3%	9%
4	ACT	13%	7%	0%
5	NSW	10%	0%	4%
6	BULLS	4%	0%	13%
7	HIGHLANDERS	11%	6%	0%
8	REDS	7%	0%	2%
9	STORMERS	0%	12%	11%
10	CHIEFS	10%	5%	0%
11	SHARKS	11%	17%	11%
12	CATS	6%	0%	0%

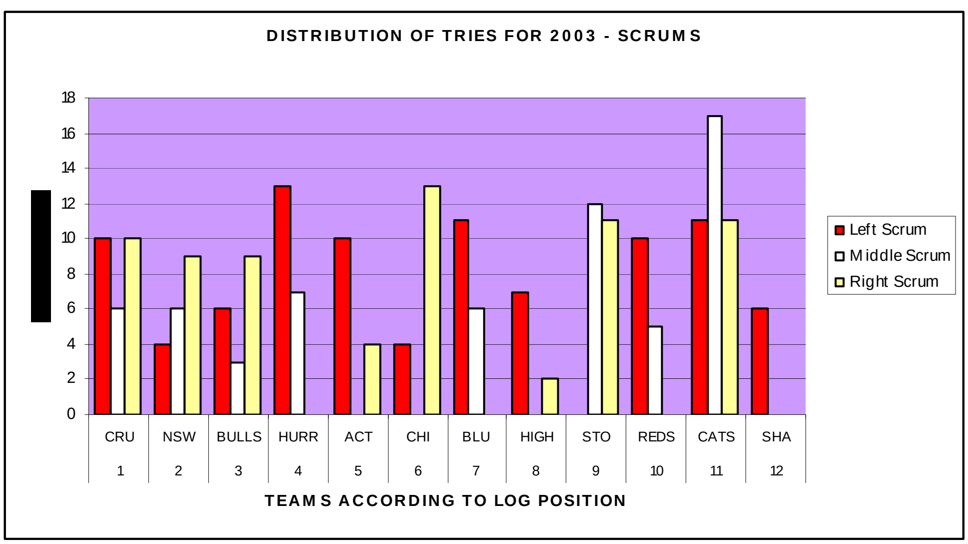


Figure 9.11: Distribution of tries scored for 2003 - scrums

As is evident from Table 9.8 and Figure 9.11, a greater percentage of tries evaluated were scored from left hand scrums.

Table 9.9: Distribution of tries scored as a percentage: 2004 – scrums

DISTRIBUTION OF TRIES SCORED AS A PERCENTAGE: 2004 - SCRUMS				
LOG POSITION	TEAM	LEFT SCRUM	MIDDLE SCRUM	RIGHT SCRUM
1	ACT	13%	0%	6%
2	CRUSADERS	14%	4%	0%
3	STORMERS	5%	0%	0%
4	CHIEFS	40%	0%	0%
5	BLUES	21%	1%	8%
6	BULLS	3%	2%	8%
7	NSW	4%	1%	4%
8	SHARKS	9%	7%	0%
9	HIGHLANDERS	0%	0%	16%
10	REDS	7%	1%	6%
11	HURRICANES	7%	1%	0%
12	CATS	15%	0%	3%

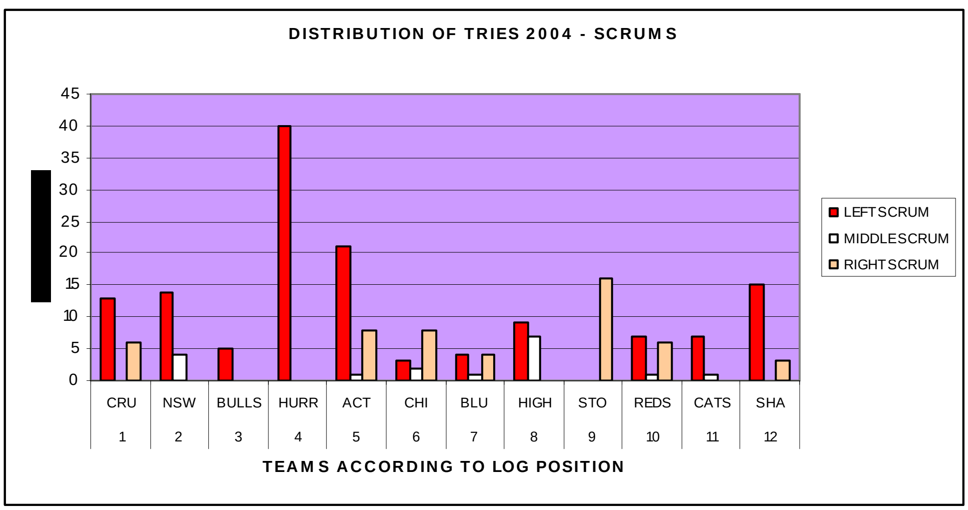


Figure 9.12: Distribution of tries scored for 2004 - scrums

As is evident from Table 9.9 and Figure 9.12, a greater percentage of tries evaluated were scored from left hand scrums.

Table 9.10: Distribution of tries scored as a percentage: 2005 – scrums

DISTRIBUTION OF TRIES SCORED AS A PERCENTAGE: 2005 - SCRUMS				
LOG POSITION	TEAM	LEFT SCRUM	MIDDLE SCRUM	RIGHT SCRUM
1	CRUSADERS	5%	0%	4%
2	NSW	10%	1%	6%
3	BULLS	7%	8%	0%
4	HURRICANES	5%	1%	4%
5	ACT	7%	0%	4%
6	CHIEFS	11%	0%	0%
7	BLUES	15%	0%	4%
8	HIGHLANDERS	6%	5%	0%
9	STORMERS	26%	5%	0%
10	REDS	16%	0%	15%
11	CATS	14%	0%	0%
12	SHARKS	7%	6%	0%

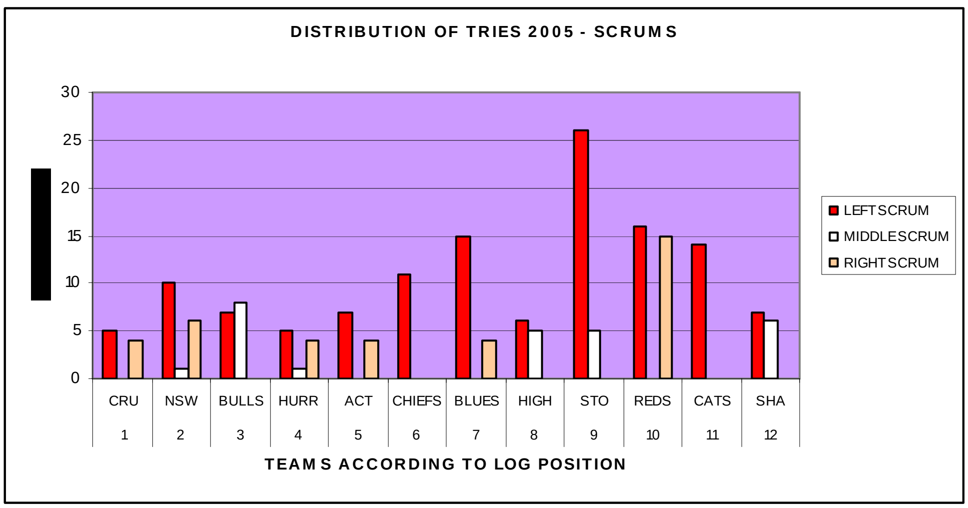


Figure 9.13: Distribution of tries scored for 2005 - scrums

As is evident from Table 9.10 and Figure 9.13, a greater percentage of tries that were evaluated were scored from left hand scrums.

Table 9.11: Tries scored as a percentage; 2003 – lineouts

TRIES SCORED AS A PERCENTAGE; 2003 - LINEOUTS			
Log Position	Team	Left Lineout	Right Lineout
1	CRUSADERS	13%	13%
2	BLUES	18%	9%
3	HURRICANES	29%	6%
4	ACT	27%	7%
5	NSW	40%	8%
6	BULLS	14%	17%
7	HIGHLANDERS	28%	11%
8	REDS	40%	13%
9	STORMERS	0%	12%
10	CHIEFS	19%	9%
11	SHARKS	0%	6%
12	CATS	7%	0%

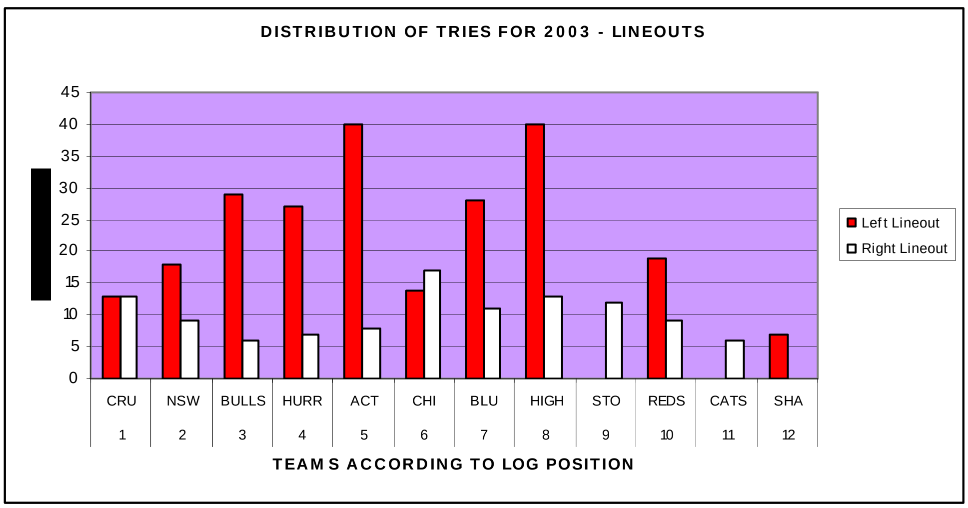


Figure 9.14: Distribution of tries scored for 2003 – lineouts

As is evident from Table 9.11 and Figure 9.14, a greater percentage of tries that were evaluated were scored from left hand lineouts.

Table 9.12: Tries scored as a percentage; 2004 – lineouts

TRIES SCORED AS A PERCENTAGE; 2004 - LINEOUTS			
LOG POSITION	TEAM	LEFT LINEOUT	RIGHT LINEOUT
1	ACT	26%	8%
2	CRUSADERS	23%	15%
3	STORMERS	36%	14%
4	CHIEFS	20%	7%
5	BLUES	33%	8%
6	BULLS	16%	21%
7	NSW	26%	21%
8	SHARKS	29%	7%
9	HIGHLANDERS	21%	5%
10	REDS	33%	9%
11	HURRICANES	27%	4%
12	CATS	8%	2%

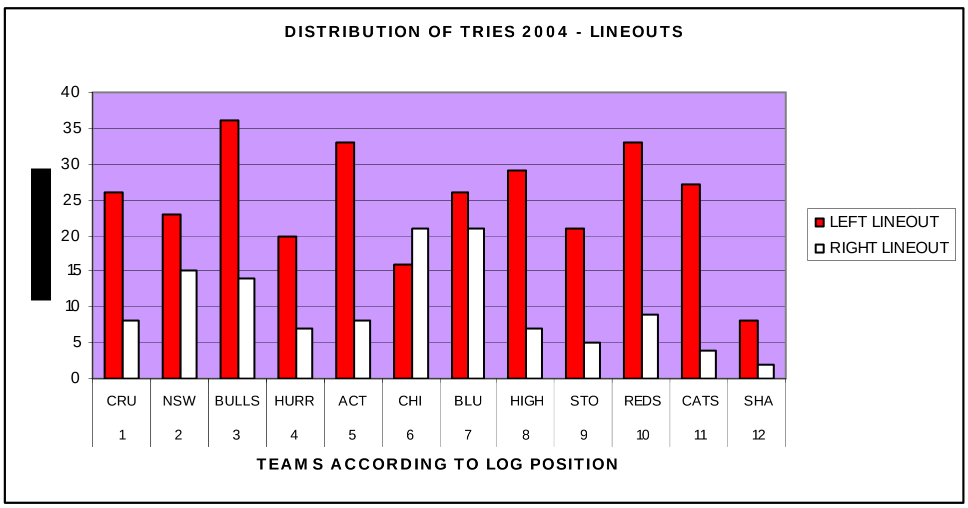


Figure 9.15: Distribution of tries scored for 2004 – lineouts

As is evident from Table 9.12 and Figure 9.15, a greater percentage of tries that were evaluated were scored from left hand lineouts.

Table 9.13: Tries scored as a percentage; 2005 – lineouts

TRIES SCORED AS A PERCENTAGE; 2005 - LINEOUTS			
LOG POSITION	TEAM	LEFT LINEOUT	RIGHT LINEOUT
1	CRUSADERS	18%	8%
2	NSW	29%	6%
3	BULLS	8%	4%
4	HURRICANES	36%	9%
5	ACT	63%	15%
6	CHIEFS	26%	10%
7	BLUES	15%	8%
8	HIGHLANDERS	28%	0%
9	STORMERS	16%	16%
10	REDS	23%	15%
11	CATS	14%	21%
12	SHARKS	25%	6%

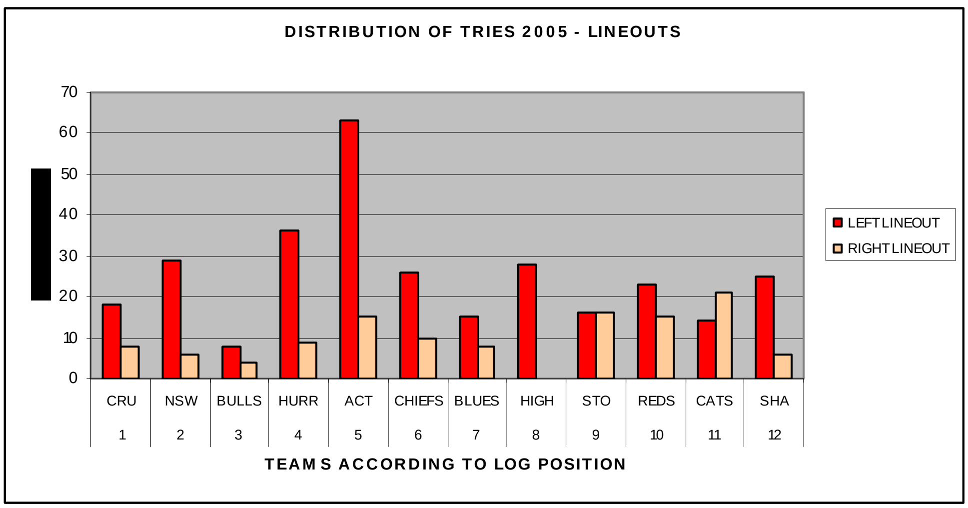


Figure 9.16: Distribution of tries scored for 2005 – lineouts

As is evident from Table 9.13 Figure 9.16, a greater percentage of tries that were evaluated were scored from left hand lineouts.

During this study, it became increasingly obvious that when defenders were forced to make tackles off their weaker shoulder, the ball carrier had a distinct advantage at the collision site. The premise is that a predominant number of players are primarily stronger and more powerful on their right shoulders when compared to their left shoulders. This situation most often took place when the ball was moved from the left hand side of the field towards the right hand side of the field, and the ball carrier came in on either an "unders" line or "overs" line. If the "unders" line is used by the ball carrier during the collision, it results in little need for the ball carrier to adjust his running line thus he can throw his maximum mass and speed into the collision. The ball carrier will also definitely run extremely hard onto the defender's weaker shoulder giving the ball carrier a distinct advantage. If the ball carrier keeps the ball tight to his chest during the collision, the balls elasticity will also aid in "bouncing" the defender off the collision. Although the defender should be able to adjust off his right leg to get into a position to make the tackle, the force and momentum exerted by the ball carrier should override and sway the advantage of the collision towards the ball carrier. If the "overs" line is used, another component applicable to collisions comes to the fore. Again the factor that the defender will be exposing his weaker shoulder to the tackle becomes evident. The tackle will however be more side-on in nature, thus the effect of mass into the collision becomes less, and the need for greater acceleration and speed in order to get away from the defender's tackling shoulder becomes necessary. The use of a hand-off from the ball carrier now becomes an effective means of keeping the defender away from the ball carrier's body and can be used as a forceful legal "punch" in order to destabilize the defender attempting to make the tackle. When the "overs" line is executed the defender will again be more agile and be better able to adjust onto the ball carrier in order to make the tackle. However, with the defender having to move sideways in order to get to the ball carrier, it becomes difficult for the defender to maintain the optimal center of gravity required to execute the successful tackle. In this specific case, the hand-off becomes an effective evasive measure.

9.5.1.6 The defender has been manipulated into over tracking by the probe used by the attacking backline and the ball carrier hits the line using the effective running line

As mentioned in the previous discussion concerning the effectiveness of a defender's tackle based on the use of his predominant or non-dominant shoulder, the concept of taking advantage of a defender over tracking on the approach to a tackle is a factor that can greatly influence the success of a collision. When the play comes from the right hand side of the field towards the left hand side of the field, results in the defender being able to make the tackle on is dominant shoulder ultimately swaying the advantage towards the defending team.

This advantage can be swayed back towards the ball carrier if they make use of attacking running and strike lines that come back onto the defenders weaker shoulders. For example, a simple switch or inside pass will result in the ball carrier running back onto the defender's weaker shoulder. If the execution is precise the added advantage of wrong-footing the defender and causing him to over-track thus manipulating his center of gravity and i.e., his stability, thus making the execution of an effective tackle by the defender all the more difficult.

An attacking backline and those players used to carry the ball into the various collisions must be aware of these factors in order to make each attack and collision as successful as possible. By this awareness, the ball carriers can nominate and execute the most appropriate running line in order to get the best result from the collision.

9.5.1.7 The ball carrier entering the collision site with his full mass moving through the line of application of the defender

The key to dominating a head-on collision is to ensure that the ball carrier ensures that his full body mass is forced upon the defender. By doing this, the defender has to execute the tackle perfectly in terms of his maximum mass in line with the ball carrier, his center of gravity perfectly in line and in front of his body, able to move into the tackle and isn't flat footed, able to manipulate the tackle situation in such a way that he can tackle with his dominant shoulder and to top it all off, that he is physically up to it to make the tackle! If all of these factors are not in place, it becomes increasingly difficult for any defender irrespective of how effective he is in executing a tackle to actually pull off a collision stopping collision.

The ability of the ball carrier to manipulate his body so that he can compact himself in order to manipulate his bodies surface area to be smaller, thus making the execution and driving of his mass "through" the defender more effective. The ball carrier also needs to be adept at setting his collision target through and behind the defender. What this implies is that the execution line of the ball carrying collision must be through and up the defenders body, maintaining maximum momentum, as well as maintaining an explosive continued leg drive so that after the initial impact at the collision site, that the ball carrier maintains forward momentum through the defender.

The initial impact will destabilize the defender, and the continued leg drive will then take advantage of the destabilized defender's body positioning and thus drive home the forward momentum. This is achieved by planting the ball carrier's driving foot as close as possible to the tackler's body. By achieving this, the ball carrier will maintain a maximum stable body positioning throughout the whole course of the collision.

9.5.1.8 The ball carrier is physically bigger and more powerful than the defender

Although the contracting of players will ultimately determine the quality, size, strength, speed and explosiveness of the players, this aspect can also be improved through the continued use of effective strength and conditioning programs.

If one considers that the game is ultimately one where the strongest and most powerful teams tend to be the most successful, it becomes increasingly obvious that the aspect of creating a unique breed of rugby player is crucial in the continued success of any team that wishes to dominate world rugby. The key however is the effective coaching of the players so that they are able to apply this strength in a rugby situation. Often teams are filled with huge players but they either don't know how to apply this strength or they do not possess the inherent desire required to be aggressive and determined to dominate the opposition in all the physical aspects of the game. Rugby is a physical game, and no amount of strength or speed can factor out desire. Even the smallest player with the necessary desire will stop a bigger player with any means at his disposal, even if it means allowing the huge ball carrier to fall over him. Stopping the opposition is key, whichever way you choose. The same desire is applicable for the ball carrier.

A decision has to be made that irrespective of how many defenders are in front of him, how many defenders are clinging to him or how big or powerful the defender is, if the ball carrier wants to dominate the collision and press forward he can and he must.

9.5.1.9 The ball carrier has a player/s leached to him thus doubling the mass of the ball carrier into the collision

As mentioned earlier, the ball carrier's ability to force his maximum mass into the collision plays a huge part in successfully dominating a collision. This type of "leaching" can be used from both quick and slow ball, and if it is effectively exploited, can be very rewarding.

In this situation if a ball carrier has a supporting player bound behind him helping him drive up and through the defender, the increase in mass makes it even more difficult for the defender to stop the forward momentum. The forward drive is aided even more if the ball carrier and the player driving behind him maintain an effective leg drive; the increase in forward force is dramatically increased.

It is also vital that the ball carrier maintains effective ball control, maintaining an effective arm driving action as the defenders will aim to wrap up the ball and thus slow the ball down when the mini-maul is taken to ground. In addition to the increase in mass and thus momentum, the ability to recycle the possession quickly and effectively becomes apparent if the carrier keeps working with his arms and the leached players drive any excess opposition players away from the collision area. The reason for this is that the cleaners are on the ball carrier's behind, and thus the opposition players wishing to slow down and steal the ball are not given an opportunity to even come close to the ruck situation.

9.5.1.2 The repeated execution of collisions that in effect soften up the opposition before the final knock-out blow is issued

When Table 8.1 and Figures 8.8 (a,b,c) (Chapter 8), were evaluated the importance of continued pressure on the defense in regards to maintaining possession became obvious. The following discussion spreads more light on the topic.

As is evident in most sports where body contact and collisions take place, the team or players that can effectively and consistently make "hits" on the opposition in such a fashion that the opposition feels the continued force and "pain", will be the most successful. The reason for this is that the energy used to absorb the collision takes more out of the player than the energy used to apply the force and collision. As shown in the study, the teams that can apply the most collisions are the ones that tend to be the most successful. Collisions in this sense are the following:

1. dominating ball carrying collisions that lead to a ruck being formed;
2. dominating ball carrying collisions that lead to the defender being bumped off; and
3. dominating ball carrying collisions where the ball carrier is able to give an effective off-load to a support player.

9.5.2.1 Dominating ball carrying collisions that lead to a ruck being formed

The ability to effectively recycle possession after a bone crushing ball carrying collision has take place is one of the great spectacles of a match for the collision connoisseur. Seeing the cleaners flying in through the imaginary gates enforced by the referee cleaning away anyone trying to get their hands on their possession really does set the tone of a match. It is one of the few legal situations where a player without the ball can be driven into in order to make your physical presence felt. Rugby is about dominance! Whether it be physical, or from the sheer speed shown by a team, the weaker team must know that they are no match for the team whose sheer purpose is dominance.

The problem arises most often in that the most teams attempt to make use of speed dominance before the physical standard has been set. A team's ability to keep on driving into the opposition being supported by hungry players wanting to clean-up any lurking players around the fringes effectively softens up the opposition. When the ball is eventually moved around, the defending team's legs start to feel like jelly, and the effectiveness of the attack becomes even more apparent. This aspect of play if the teams are conditioned to do it effectively, and if discipline is maintained is a huge part of a successful team's armory.

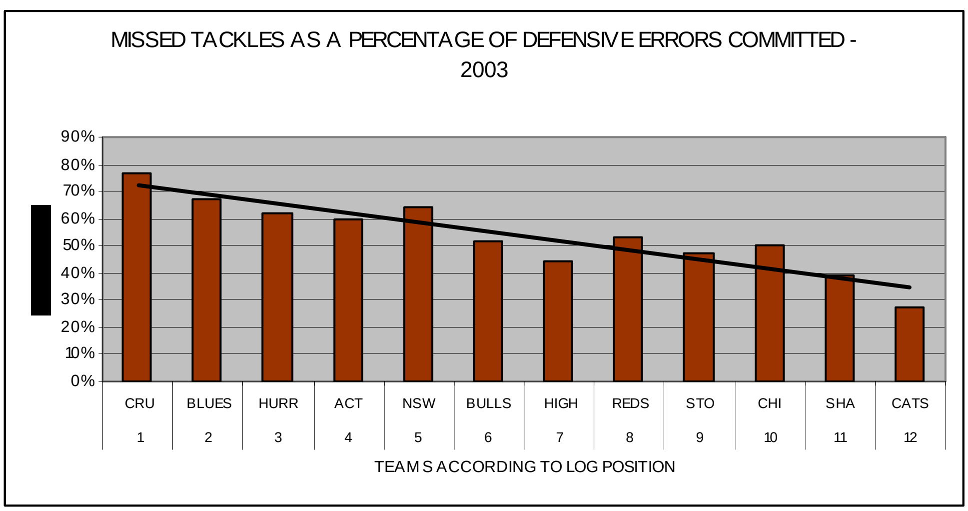
9.5.2.2 Dominating ball carrying collisions that lead to the defender being bumped off

After evaluation of the following data statistics that were compiled during the three years of Super 12 competitions, missed tackles as a percentage of defensive errors made by the defending team indicated the importance of being able to knock over defenders during attacking play.

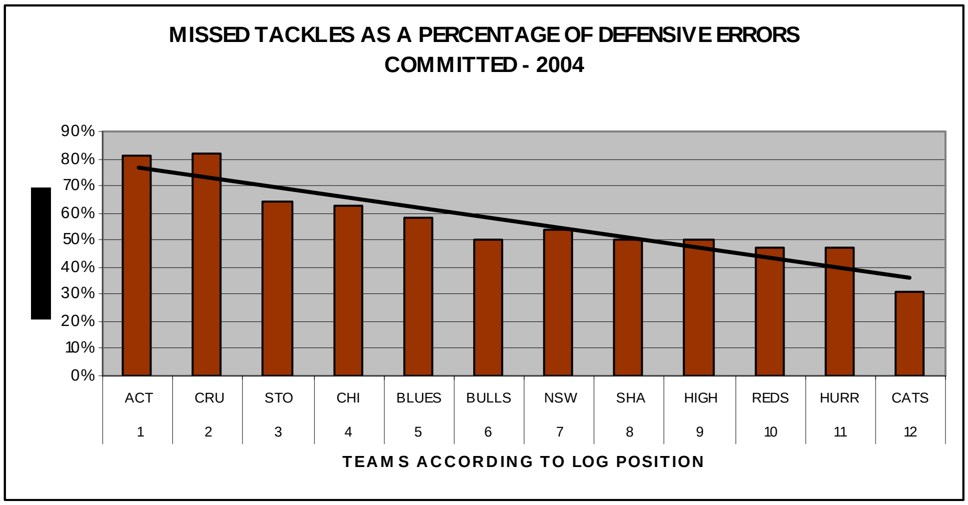
Table 9.14: Missed tackles as a percentage of defensive errors committed

MISSED TACKLES AS A PERCENTAGE OF DEFENSIVE ERRORS COMMITTED												
2003	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	BLUES	HURR	ACT	NSW	BULLS	HIGH	REDS	STO	CHI	SHA	CATS
PERCENTAGE	77%	67%	62%	60%	64%	52%	44%	53%	47%	50%	39%	27%
2004	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	ACT	CRU	STO	CHI	BLUES	BULLS	NSW	SHA	HIGH	REDS	HURR	CATS
PERCENTAGE	81%	82%	64%	63%	58%	50%	54%	50%	50%	47%	47%	31%
2005	1	2	3	4	5	6	7	8	9	10	11	12
TEAM	CRU	NSW	BULLS	HURR	ACT	CHI	BLUES	HIGH	STO	REDS	CATS	SHA
PERCENTAGE	90%	81%	76%	77%	67%	65%	50%	44%	53%	54%	43%	44%

(a)



(b)



(c)

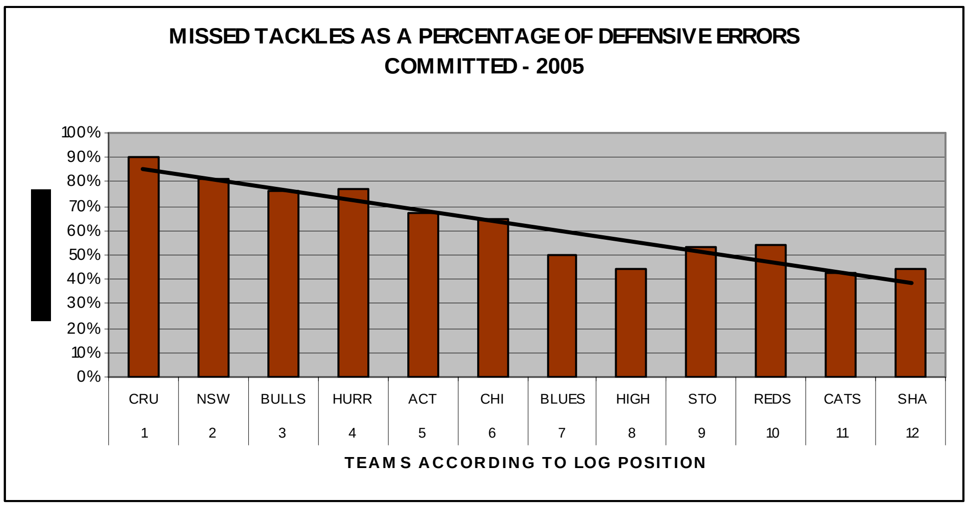


Figure 9.17 (a,b,c): Missed tackles as a percentage of defensive errors committed – 2003, 2004 and 2005

As is evident from Table 9.14 and Figure 9.17 (a,b,c) the teams ability to dominate collisions by knocking over defenders certainly influenced the final log position attained during the three Super 12 competitions.

A defensive team finds itself under extreme pressure when their defenders start falling off tackles. The reason for this is that the defenders start shirking their duties which results in extra pressure being applied to the other defenders who have to in turn make the tackle which should have been made earlier. This ultimately results in insufficient resources to cover the field defensively and defensive holes start to present themselves all over the field. Apart from defenders whose system gets shuffled due to the missed tackles, the mental dominance that is experienced by the defenders is huge. The defenders start becoming jittery and there is constant doubt in each player's mind as to can they "trust" their teammate to make their tackle, or will they have to adjust in order to cover up for fellow teammates? This mental barrage that teams experience starts to impact on almost all aspects of their play, whether it be primary phases, decision-making, execution or merely concentration during the match. Again, the team that dominates the opposition can absorb the pressure without losing their shape and concentration, and who can apply pressure constantly will ultimately breakdown the opposition. This is the key determinant of success!

9.5.2.3 Dominating ball carrying collisions where the ball carrier is able to give an effective off-load to a support player

The most disorganized defensive lines and the greatest opportunities to punish the defense occur around the ruck. The reason for this is that the defenders need to realign and fold as appropriate which, if it occurs slower than what the attacking supporters can get to the area will result in holes through which the attacking team can punch. It does however also present the most amount of "traffic" in a very confined space, which means that the execution is crucial in order to get the ball to the appropriate player.

Support from depth is crucial in such situations; this implies that the supporters must come in directly from behind so that the small space can be truly exploited. If the attacking team can maintain their forward momentum through this channel, with there supporters and cleaners working hard to maintain quick and efficient possession, the defensive wall most certainly burst open. In conclusion, if a team keeps punching away at the opposition, getting in effective physical hits, (in an appropriate and legal manner), and no opposition can maintain their defensive qualities for such a prolonged period of time. Ultimately, the teams that can execute this strategy will be the ones that are successful.

9.6 CONCLUSION

When all is said and done, it remains the team and coaching staff's responsibility to identify and incorporate what is their attacking strategy and how that strategy is to be incorporated into their playing structure. Collisions in rugby cannot be avoided, what also becomes evident that there are far more collisions taking place in a match that any other skill. For this reason, it is of vital importance that this skill is acknowledged as vital to the success of rugby and the training of this skill become more prevalent in rugby sessions.

In concluding the study the following key factors have come to the fore during the evaluation of the available data and been identified by the author as important key coaching areas for coaches to focus on during training sessions and matches.

- Have a clear understanding of where tries originate from and empower the players to dominate that aspect of the play, this implies that as most tries were scored from turnover possession, players should be coached as how to effectively attack from this turnover possession gained and in turn when attacking to be very accomplished at maintaining and recycling their possession so that it is not turned over thus giving the opposition exceptional possession from which to attack;
- Become a student of the game identifying those scientific aspects that, if implemented could make a difference to the improved performance of the player and the team;
- Have the ability to make use of the "art" of conveying information to the player or team in such a way that it can be implemented and executed successfully;
- Empower the player and team to be able to perform in a structured environment that does not overbear the players creativity but in fact gives the player or team the parameters within which this creativity can be effectively displayed;
- Empower players to be able to use effective footwork while entering the collision site in order to be able to manipulate defenders and thus be more adept at dominating the collision;
- Empower players to be able create attacking "quick" ball and be able to regenerate slow ball if required;

- Empower players to be able to take maximum velocity into a collision if the situation requires it;
- Create attacking situations where defenders are forced to make tackles with their "weaker" tackling shoulders;
- Empower players and teams to be able to use optimal running lines in order to weaken defensive lines and manipulate defenders to such an extent that their tackle technique is compromised;
- Empower players and teams to be able to maintain and recycle possession effectively while attacking;
- Empower players to be able to maintain the attacking momentum by being able to make knowledgeable off-loads at appropriate times with the necessary precise execution; and
- Ensure exceptional recruiting skills by identifying the biggest, strongest, most athletically powerful, mentally durable and skillful players in order to put together a successful team.