An improved system for the computation of target scores in interrupted limited over cricket matches adding variations in scoring range as another parameter

For fixing target scores in interrupted limited over cricket matches, the International Cricket Council (ICC) has been using the Duckworth–Lewis (D/L) method[1] since October 1998. However, many experts have rated[2–4] the 'VJD-system'[5] to be a better system. While the D/L system was consistently failing to give good results even when the score starts exceeding 260–270 runs, the VJD-system was giving almost impeccable results for a range of 150–325 runs and reasonable results for another ± 50 runs. While further improvement in the VJD method by incorporating the scoring rate as an additional parameter was contemplated earlier, this was not put to practice because one of the major conditions of ICC was that the system should be usable with only a pocket calculator (i.e. without the help of a computer). Now ICC has changed its policy and is willing to permit the use of a computer for obtaining better results. This has now given an opportunity to make further improvements in the system and make it perfect even in the cases of abnormally high and low scores. Just as the manual system proposed by the author was clearly superior to the manually operated D/L system, the improved system presented here is also seen to be better than the computerized system now being implemented by the ICC (as can be seen from the comparison of some of the results described below). The additional advantages of the system are: (1) It is *fully transparent* and understandable; (2) Though it is presented as a computerized method, it is not impossible to operate it manually.

This method is also based on the concept of *normal* and *target* scores. All the concepts and assumptions in the original method[5] in connection with the fall of wickets, minimum % of normal scores per fall wickets are applicable to this system also. The major difference is that in the original method, while one single target table decides the scoring pattern, in this case 'that one target table' is selected from 501 tables. In other words, the new system identifies the differences in scoring patterns in a 100 runs scored match from that in a 200, 300 or 400 runs scoring match. More precisely, in a 210 runs scoring match and in a 211 runs scoring match the target tables used will be different.

From the available data, the scoring pattern in matches of scores of around 200, 250 and 300 runs are worked out and the target tables are developed. Theoretically in a '1800 runs' scored match, the normal and target curves merge and it would be a straight line making 45° with the axes ($y = x$). Similarly in a '0' run scored match the normal and target curves lie along the X-axis, as 1 run is the requirement for victory. Based on these concepts, the data for 100, 400, 500 runs, etc. are generated. It is assumed that a score beyond 599 tends to impossibility in a 50 over match and the condition applicable for 1800 is brought down to any score of 600 and above. Also for simplicity it is assumed that the table for 100 runs can be used for any score below 100 runs.

It is found that the table for 250 runs lies very near the target table of the original method and also it is very nearly the same as the average of the tables for 200 and 300 runs. So it was decided to use 6 tables, as they are sufficient to provide the entire data bank of the method. The data used to develop the regression equation of a cubic curve passing through (0, 0) and (100, 100) and the coefficients of x, x^2 and x^3 are furnished in Table 1. Similarly the same data, rearranged in the descending order of scoring rate to develop the target curves, and the regression coefficients arrived at are furnished in Table 2. As already explained above, the line $y = x$ passing through the origin serves both as the normal as well as target curve for a score of 600 and above.

Using these regression coefficients, and retaining the same assumptions made regarding the minimum requirement of normal score with fall of wickets as before (see table 4, ref. 5), six target tables are developed. The computer program developed for the original method was modified in this improved version by including a new subroutine to read these 6 tables from a data file. For scores below and up to 100 runs the table for 100 runs (say t-100) is used and for scores from 600 runs onwards t-600 is used. In between, for each run the table will be different (totally another 499 tables) and this subroutine will generate by linear interpolation the required table. The rest of the calculations remain the same as that of the original method.

As an illustrative example, consider the following match from World Cup 2003: When Australia makes 359 in 50 overs, what is the winning score for India in 25 overs for the loss of 3 wickets?

From t-300, the normal score % for 3 wickets = 46%.

From t-400, the normal score % for 3 wickets = 48.1%.

Hence for the t-359 the normal score will be 46 + (48.1–46)*(59/100) = 47.24%.

Table 1. Data and regression analysis for normal score curves

% Overs		Percentage normal scores for different scoring ranges				
		100 and below	200	300	400	500
10		6	7	9	10	10
30		27	30	32	31	31
50		41	43	47	48	49
70		56	58	64	66	68
80		68	60	76	77	79
90		81	83	86	87	89
Regression coefficients	x	1.090272	1.20965	1.26713	1.15522	1.09592
	x^2	–0.01092	–0.01239	–0.01119	–0.00619	–0.00345
	x^3	9.93E–05	0.000103	8.5E–05	4.6E–05	2.5E–05

Table 2. Data and regression analysis for target score curves

% Overs		Percentage target scores for different scoring ranges				
		100 and below	200	300	400	500
10		19	17	15	13	11
20		33	31	28	24	22
30		45	44	42	38	34
40		55	54	52	48	44
50		65	64	62	58	54
60		73	73	72	68	64
70		81	81	80	78	74
80		88	88	87	85	82
90		95	94	93	92	91
Regression	x	1.884093	1.750051	1.573917	1.31853	1.156579
coefficients	x^2	–0.01435	–0.01098	–0.00724	–0.00281	–0.00138
	x^3	5.59E–05	3.49E–05	1.47E–05	–4.3E–06	–2.2E–06

Winning score for India = 359*47.24/100 = 169.59 = 170 runs.

Table 3 gives a comparison of results evolved from the four methods based on many real as well as hypothetical situations. Based on an analysis of these, as well as other situations, it is strongly felt that even the new computerized system employed by D/L is not up to the expectations. The results of this Professional Edition give a clear indication that the D/L Standard Edition, which was followed by the ICC since October 1998, looks quite inferior even after the 2002 revision. Also some of the results indicate that even the professional edition is not free from the controversial G50. On

Table 3. Comparison of the results of the four methods in discussion

Sl. no.	Situation	DL (M) target	DL (C) target	VJD (O) target	VJD (N) target
1.	Team-1: 300 in 50 overs. Interruption occurs when team-2 completes 25 overs without losing any wickets. Winning score of team-2	101	115	122	126
2.	Team-1: 300 in 50 overs. Target for team-2 in 25 overs	200	186	191	188
3.	Team-1: 50/0 in 25. Target for team-2 in 25 overs?	128	128	79	87
4.	Team-1 after 25–100/0 when their innings terminated. Target for team-2 in 25	178	163	157	159
5.	Team-1 when 60/0 in 20, match reduced to 35 over a side. Team-1 make 150 in 35. Target for team-2 in 35	180	180	161	161
6.	New Zealand after 27,2 were 81/5 when one over lost and then at 114/5 in 32,4 overs their innings terminated. Target for South Africa in 32	147	147	128	131
7.	India 226/8 in 47,1 overs. Target for Pakistan in 33	194	193	185	185
8.	England 176/5 after 36,5 overs when match rescheduled to 46. Then after 37,5 overs when England were 181/5 again rescheduled to 40 overs. England make 193/6 in 40	220	218	212	211
9.	New Zealand 212/5 in 44,2 overs. Target for W.I. in 33 overs	204	200	199	198
10.	LOI#1442. Australia make 252 in 50. WI in reply were 138/1 in 29. 10 overs are lost. Target for WI in 40 overs	196	196	208	208
11.	WC-2003: South Africa 306 in 50. New Zealand 182/1 in 30,3 overs. Target in 39 overs	227	230	242	244
12.	WC-2003: Australia 212 in 50. Winning score for Sri Lanka in 38,1 overs for 7 wickets	172	176	173	174
13.	Australia 359 in 50. India winning score in 25 overs for the loss of 3 wickets	158	176	160	170
14.	Team-1 450 in 50 overs, target for team-2 in 25	300	248	286	252

DL (M), The Duckworth–Lewis manual method (standard edition); DL (C), The Duckworth–Lewis computerized method (professional edition); VJD (O), The author's original method; VJD (N), The author's new method.

the other hand, except for really high or very low scores (Nos 3, 13 and 14, Table 3), the results of the systems developed by the author are neck to neck, highlighting the basic soundness of the approach as well as the robustness of the method.

While most such calculations are straightforward, since this improved version requires the target table to be chosen based on the first inning total, two new issues have to be dealt with.

– In the beginning itself, if the match is a shortened one, how to make the table selection.
– When the interruption occurs while team-1 is batting, how to select the table.

The following procedure, developed after considerable experimentation is seen to provide an almost perfect solution.

For the first case, the target table corresponding to 300 runs can be used as an average table; and from the target score % column the value to be applied for projecting the score can be picked up. For example if it is a 45 over a side match in the beginning and the team-1 has scored 200 runs in 45, the table to be used would be the one corresponding to '200 divided by target % for 90% of overs from t-300'. That is, the one corresponding to 200/0.937 = 213 runs. If, instead of t-300, t-200 were used, still the result that works out would be to use t-213 itself. This reveals that the error involved in this approximation is quite negligible.

For the second case, again the initial projection is done using t-300 and then the entire calculation is repeated using the new selected table to find out the new projected score. If necessary, further repeated calculations (iteration) can be employed till two projected scores converge. However, by experience, just one iteration of the calculation is generally seen to be good enough to give sufficiently accurate results. The following illustration is helpful to clarify the approach. When New Zealand scores 212/5 in 44,2 overs, what should be the target for W.I. in 33 overs?

First use t-300 for the projection.

As per t-300, normal score for NZ in 44,2 (88.66%) overs = 83.86%.

Hence projected score of NZ in 50 overs = 212/0.8386 = 252.80.

Table to be used for the final calculation = t-253.

Normal score % in 44,2 overs as per t-200 = 81.9%.

Hence normal score as per t-254 = 81.9 + (83.9–81.9)*(53/100) = 82.96%.

Target score in 88.66% as per t-300 = 92.8.

Target score in 88.66% as per t-200 = 93.2.

Hence as per t-253 it will be = 93.2 + (92.86 – 93.2)*(53/100) = 93.02%.

Target for W.I. in 44,2 overs would be = 212*(93.02/82.96) = 237.70.

As per t-253, for 33 overs the target will work out to be $(t_{33}/t_{44,2})$ = 77.1/93*100 = 82.9.

Hence the target score for W.I. in 33 overs = 237.70*0.829 = 197.06 = 198 runs.

That the system should be manually workable using not more than a pocket calculator was one of the main conditions imposed by the ICC so far. Within this constraint, the original system proposed was performing exceptionally well though the authorities gave little recognition to it. This new system is again very transparent, flexible and reliable for any range of scoring including very low or very high scoring. Since the systems proposed by the author always have the advantage of considering the scoring pattern of the team, including the effect of field restrictions, it is felt that these are better systems than the corresponding D/L systems.

1. Duckworth, F. C. and Lewis, A. J., *J. Oper. Res. Soc.*, 1998, **49**, 220–227.
2. Anand Parthasarathi, *The Hindu*, 24 September 2002.
3. Pallava Bagla, *Indian Express*, 6 October 2002.
4. Ramachandran, R., *Frontline*, 6 December 2002.
5. Jayadevan, V., *Curr. Sci.*, 2002, **83**, 577–586.

ACKNOWLEDGEMENT. I thank Dr Frank Duckworth for results of different cases as per their standard system as well as the new professional (computerized) system.

Received 15 October 2003; revised accepted 16 January 2004

V. JAYADEVAN

156, Nehru Nagar,
Thrissur 680 006, India
e-mail: trc_vjd@sancharnet.in

Cancer epidemiology, prevention and control

N. S. Murthy and Aleyamma Mathew*

Chronic diseases such as cancer, and other non-communicable diseases are fast replacing communicable diseases in India and other developing countries. We deal here with the epidemiology of cancer, its control and prevention measures as applicable to Indian situation. Tobacco is the most important identified cause of cancer followed by dietary practices, inadequate physical activity, alcohol consumption, infections due to viruses and sexual behaviour. Cancer prevention includes primary and secondary prevention measures. Public education on 'tobacco and its health hazards', recommended dietary guidelines, safe sexual practices, and lifestyle modifications form the main features of primary prevention of cancer. Incorporating screening for cancer of cervix, breast and oral cancers into peripheral health infrastructure can have a significant effect on reducing mortality from these diseases.

THE burden of cancer is still increasing worldwide despite advances for diagnosis and treatment. Epidemiological studies have shown that many cancers may be avoidable. It is widely held that 80–90% of human cancers may be attributable to environmental and lifestyle factors such as tobacco, alcohol and dietary habits[1]. Cancer prevention includes primary, secondary and prevention methods. Primary prevention refers to avoiding cancer-causing substances in the environment or dietary elements associated with increased risk; dietary supplementation with putative protective agents. Secondary prevention aims at early detection and removal of benign tumours of oral, cervical and breast cancers[2]. It was estimated that in the year 2000, worldwide over 10 million new cases of cancer occurred (approximately 5.3 million men and 4.7 million women) and over 6 million people died from cancers[3]. The most frequently affected organs are lung, breast, colon, rectum, stomach and liver. Epidemiology of cancer, its control and prevention measures as applicable to Indian population have been discussed here.

Cancer epidemiology

Demographic shift

Urbanization, industrialization, changes in lifestyles, population growth and ageing all have contributed for epidemiological transition in the country. The absolute number of new cancer cases is increasing rapidly, due to growth in size of the population, and increase in the proportion of elderly persons as a result of improved life expectancy following control of communicable diseases. In India, the life expectancy at birth has steadily risen from 45 years in 1971 to 62 years in 1991, indicating a shift in demographic profile[4]. It is estimated that life expectancy of Indian population will increase to 70 years by 2021–25 (ref. 5). Such changes in the age structure would automatically alter the disease pattern associated with ageing and increase the burden of problems such as cancer, cardiovascular and other non-communicable diseases in the society.

Cancer registration: Population-based cancer registry (PBCR) is the source of data in estimating the incidence and mortality as it records all cancer cases occurring in a defined region. The Indian Cancer Society started cancer registration in India by initiating PBCR in the city of Mumbai during the year 1963.

Keeping in view the paucity of reliable data in a country with wide socio-cultural diversity, the Indian Council of Medical Research (ICMR) initiated a network of cancer registration through the National Cancer Registry Programme (NCRP) in 1982 to set up cancer registries in different regions of the country. The ICMR network of registries now consists of 6 PBCRs located at Bangalore, Bhopal, Chennai, Delhi and Mumbai (5 urban) and Barshi (rural). There are some other PBCRs in Kerala (Thiruvananthapuram and Karunagapally), West Bengal (Kolkata), Gujarat (Ahmedabad), and Maharashtra (Pune, Nagpur and Aurangabad), which are not under ICMR. Although the population covered by the above registries is very limited, to the extent of only 5%, it gives some idea of the extent of the cancer problem in the country[6].

N. S. Murthy is in the Institute for Cytology and Preventive Oncology, Maulana Azad Medical College Campus, BSZ Marg, New Delhi 110 002, India; Aleyamma Mathew is in the Division of Epidemiology and Cancer Research, Regional Cancer Centre, Medical College Campus, Thiruvananthapuram 695 011, India
*For correspondence. (e-mail: nsmurthy44@yahoo.com)