Effects of different handle techniques during the back pull exercise on the angular kinematic and production of strength

Luciano P. da Silva[1]
Juliano Dal Pupo[2]
Josiele V. Alves[2]
Carlos B. Mota[2]

[1] *Federal University of Santa Catarina Brasil*
[2] *Federal University of Santa Maria Brasil*

ABSTRACT

The present investigation aims to verify the kinematic pattern of movement in the back pull exercise through the evaluation of the articular angle of the joint of the elbow and shoulder between two different handle techniques in the bar: open and closed, considering the spans of the individuals. Furthermore, the possible interference about these different techniques on the maximal dynamic strength (MDS) and the located muscular resistance were related. The bidimensional videography with a camera operating at the frequency of 60Hz was used to capture images which were later analyzed and processed by the Peak Motus System. Twenty six (26) young individuals of both sexes took part in the kinematic analysis of the movement, 11 male individuals for the determination of the maximum dynamic strength and 10 also male for the determination of the located muscular resistance. The indicates significant angular discrepancies among the distinct handle techniques for each involved joint (elbow and shoulder). The closed handle technique has presented a largest flexion angle at the end of the movement for the elbow joint, witch implicate a higher acting of the flexor muscles on that joint. The results have also showed that the size of the span exerts influence on the articular movement as long as the bar remains with the same length for all individuals. For the maximal dynamic strength the individuals have achieved a better result on the through the closed handle technique unlike the behavior of the strength of located muscular resistance where the individuals have achieved a better result through the open handle.

Key-Words: *resisted exercises with weight, kinematic, back pull exercise*

RESUMO

Análise cinemática de duas técnicas de "pegada" no exercício puxada alta

A presente investigação objectivou investigar, no exercício com pesos denominado "puxada alta", os ângulos articulares do ombro e cotovelo em duas diferentes técnicas de pegada: aberta e fechada, considerando a envergadura dos indivíduos e ainda verificar a interferência desta técnicas na força máxima e força muscular localizada. Para análise cinemática utilizou-se videografia bidimensional e um teste de 1RM e RMs para determinar a força máxima e de resistência, respectivamente. Participaram deste estudo 26 indivíduos de ambos os sexos para realizar a análise cinemática, 11 indivíduos do sexo masculino para determinação da força máxima e 10 para a força de resistência muscular localizada. Os resultados mostraram que na técnica de pegada fechada houve maior flexão do cotovelo no final do movimento, implicando maior acção dos músculos flexores desta articulação. O tamanho da envergadura também influenciou nos ângulos articulares, mostrando que os indivíduos de maior envergadura tendem a flexionar mais o cotovelo no fim do movimento. Em relação à força máxima, os indivíduos tiveram melhor desempenho na técnica de pegada fechada, enquanto que na força de resistência muscular o melhor desempenho foi na pegada aberta. Conclui-se que as variações nas técnicas de execução podem ser um factor interveniente no treinamento resistido com pesos.

Palavras-chave: biomecânica, cinemática, exercícios com pesos

INTRODUCTION

Resisted exercises with weights (REW) have been attracting a large number of practitioners in order to avoid diseases, health promotion, aesthetic, competitive reasons and for leisure only (8). The popularity of this practice has increased mainly, due to the fact that several researches had demonstrated the benefit from this activity. That activity makes use of external overloads in order to offer resistance to the muscle making them able to be applied in several ways among which stand out the free loads or the specific machines.

It is essential to know the biomechanical and kinesiologic bases in order to allow a perfect accomplishment of the movements in REW. A better knowledge about these areas will permit a critical evaluation of the applied techniques and, thus, carry out a better prescription of the exercises, besides, correcting postures and preventing lesions (14). Kinesiology is an area which provides a deep understanding about the human movement. The kinesiologic analysis allows to know the acting muscles in certain movements, as well as distinguishing the agonists, the antagonists and the synergists of the movement (12).

Kinesiologic analysis intends to determine the characteristic muscular activity during the specific phases of the acting and the movements of the joints. One of the methods applied on this analysis is the use of kinematics joined to videography. The digitalization of these recorded images allows the data obtaining which provides subsidies for a full and objective description of the movement (8, 22, 11).

The human body movements work through a bio-crowbars system which is established according to physical principles (2,4). The angular variations or the width degree adopted in certain exercises can exert influence on the training in REW regarding the muscular action and also the strength production (15).

The shoulder adduction on the vertical puller referred as "back pull with high pulley" (6) is one of the more frequently applied exercises inside the REW room. Thus, we can observe the importance of biomechanics/kinesiologic analysis for the efficiency and safety of this exercise. According to the literature (18) this exercise intends to develop the latissimus dorsi muscle but not involving the whole fibers of this muscle, emphasizing that the variation of the "handle" techniques (the way of holding the bar) would be an option for the strengthening of a certain muscular group as a whole.

The extant theoretical references about REW often provide contradictory information with insufficient scientific bases. Frequently, the literature shows simple introductions without wider and deeper explanations.

The variations on the execution technique due to the adoption of different joint angles can exert influence on the training in REW (19, 7). Thus, taking in to account that the movement width is an important intensity variable (1, 3, 5, 23, 24), the purpose of this study has been to determining the kinematic pattern of the movement developed during the concentric phase of the back pull exercise, when it is accomplished behind the head, verifying if there is any angular difference in the joint (shoulder and elbow) involved with the open and closed "handle" techniques relating with the individuals' span. Besides, we have observed the behavior of the maximum dynamic strength and the located muscular resistance strength in relation to the different types of handle.

MATERIALS AND METHODS

The present research has been developed in two stages, in order to attend to the proposed objectives. The first one was the determination of a movement pattern for the analyzed exercise. The second was the accomplishment of a maximum dynamic strength protocol (1RM test) (16) and located muscular resistance strength protocol (RMs test) (11).

Aiming to determine the angles of the joints of the shoulder and of the elbow during the accomplishment of the exercise, took part voluntarily in that research 26 individuals of both sexes (5 females and 21 males) already introduced in the REW with average age 22 ± 4,42 years. The trained/not trained factor has been unconsidered for not being an intervening variable. For the application of the one Maximum Repetition Test (1RM), were selected 11 male with average age 24,3 ± 5,2 years and for application of the Maximum Repetitions test (RMs), were selected 10 male individuals with average age 22,64 ± 3,64 years, being both groups considered trained and with at least one year of continued practice in REW.

Each individual was invited to take part in the research with a previously established schedule and they were asked to wear training clothes with men wearing no shirts and women wearing *tops* allowing, thus, the specific demarcations in the established areas to be done.
During the first stage, an angular pattern of movement for the joint of the shoulder and elbow was determined along the concentric phase (determined as a complete cycle) of the "Back pull exercise with high pulley" (6) by using two different "handle" techniques denominated opened and closed (figure1). The images captured in this stage have been made through the bidimensional videography with a camera operating in the frequency of images acquisition of 60Hz. The position angle of the camera was perpendicular to the front plan (posterior view) in which the movement took place. From these images, a process of reconstruction of the movement was made through the digitalization of the referring anatomical references. The variables have been analyzed through the *Peak Motus* system *(Peak Performance Inc 5.0, USA)*. The calibration has been made starting from an aluminum scale with two demarcations of one meter between them.
After the explanations about the procedures, the individual's span was verified by using measuring ribbon with 1mm of resolution, according portuguese protocol (9). Subsequently, external reflexive markers were fixed in the following anatomical references: medial point between the styloid process of the radio and of the ulna, right and left, lateral condile of the right and left humerus, right and left acromial process, 7th cervical vertebra, vertebra located in the medial line between the lower angles of the scapulas and right and left iliac crests.
The figure 1 shows the reflexive marks on the anatomical references, the delimiting point of the end of the movement besides the location of the "handles" for the two techniques. The elbow joint angle was defined between the markers of styloid process of the radio and of the ulna and the shoulder joint angle was defined between the markers of lateral epicondile of elbow, acromial process and iliac crests.

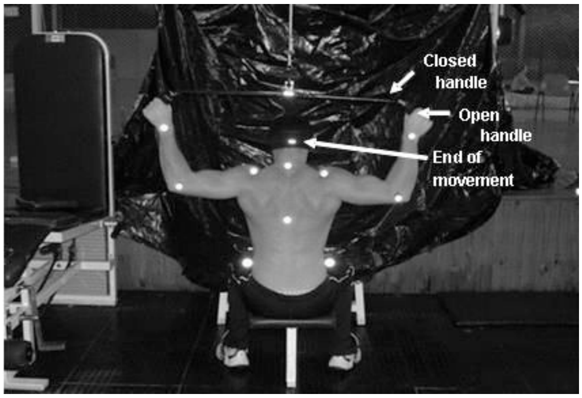

Figure 1. Illustration of the back pull exercise

Firstly, each individual has accomplished 30 complete back pull movements with an inferior load in relation to the usual training load in order to establish that as a slight load (23) starting from this number of repetitions. If the individual has been making 30 repetitions, this same load was used for record the movement. In case the individuals did not to carry 30 repetitions, the procedure with a lesser load was repeated. Soon after a small recovery interval, the individual has accomplished five complete back pull movements with a wider "handle" in the extremities of the bar, here referred as open "handle". After such repetitions were made without any interval the "handle" type was changed. Now the individual had to hold the bar more internally (closed "handle") for the accomplishment of more five complete repetitions.
It is worthwhile to emphasize that the end of the considered movement (6) (end of the concentric phase) has been predetermined through the mark placed in each individual's higher nape line, being this point aligned with the inferior lobes of the ears in the Frankfurt's plan (see figure 1).
In the second stage of the research the protocol of maximum neuromuscular progressive effort, the test of one Maximum Repetition (1RM) and the Maximum Repetitions test (RMs) has been applied, for obtaining the Maximum Dynamic Strength (MDS) and located muscular resistance strength, respectively. In the RMs test, the execution speed was controlled by one metronome in the cadence of 60 bpm.

In order to accomplish the movement of back pull the chosen equipment was the High Pulley machine of the INBAF model with lowest load of 07 kg and the maximum load of 96 kg. The bar used in this equipment is the same that is usually seen in academies (figure 1).
An average has been made for every situation of each variable movement for all individuals. Thus, average data was obtained on the way as the movement has occurred in every moment. Soon after, a *Student "t"* test has been applied to verify the existence of an angular difference between the right and the left upper limbs for the shoulder and elbow joints. Once there has been no significant difference we worked with the averages of the right and left joint.
The *Shapiro-Wilk* test showed that the dates presented normal distribution. The comparisons between the joints angles of different "handles", results of the 1RM and RMs tests were analyzed through the parametric paired *"t" test*. Aiming to analyze the influence of the spans related to different "handles", an average was made for the span of the 26 individuals and the value found was 1,80m. Thus, the group became separated in two: higher than 1,80m and lower than 1,80m. Afterwards, an analysis has been accomplished through the paired *t test* in order to verify possible differences between groups regarding the spans and the final and initial angles of movement in both techniques.

RESULTS

According to the figure 2, referring to the movement pattern for the elbow, an initial medial angulation of 150.46° was evidenced for the open "handle" technique while 148.22° was the value of the angle for the closed "handle" technique. We can notice that in the beginning of the movement the angular values of both elbow techniques were similar with a variation of 2.24° (without statistic difference).
However, the final pattern of the concentric phase shows a difference of 24.4° between the two "handle" types. The final value found for the elbow joint during the open "handle" was 83.55°, which is significantly larger ($p<0.01$) than those 59.21° found in the closed "handle".

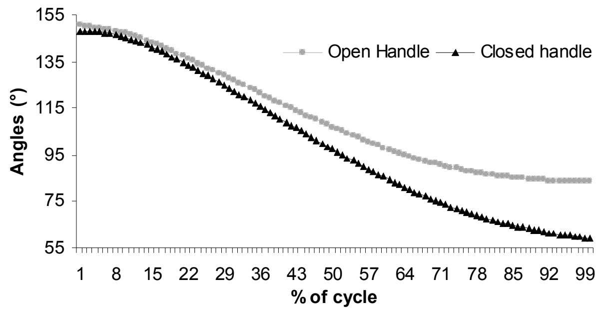

Figure 2. Movement pattern for the elbow in both "handle" techniques during the concentric phase of the exercise

On the other hand, for the shoulder joint, as it may be seen in figure 3, the movement pattern of the open "handle" exercise began with an angulation of 119.4°, unlike the closed "handle" which began with a value of 128.9°. An angular variation of 9.5°, which statistically differs to $p<0.01$, can be observed for the shoulder joint in the beginning of the exercise.
Nevertheless, the final pattern of this movement for the shoulder joint during the concentric phase was shown similar between the two adopted techniques (without statistic difference). For the open "handle" the value found was 42.64°, while in the closed "handle" was 43.82° occurring, thus, a variation of only 1.18°.

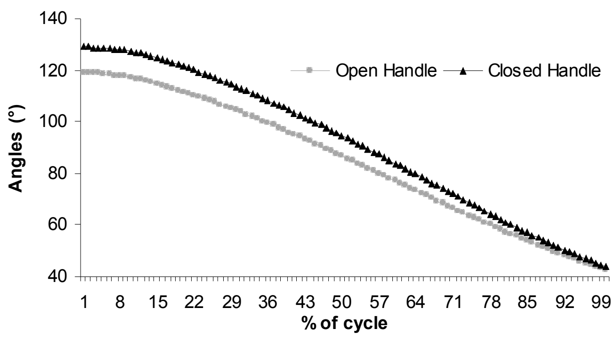

Figure 3. Movement pattern for the shoulder in both "handle" techniques during the concentric phase of the exercise

The values of the angular variables referring to the different spans in the exercise are shown bellow in the table 1.

Table 1. Angulations of the shoulder along the different spans in the beginning of the movement

Spans	O.H.	C.H.
<1.80 m (n=13)	117.62° ± 3.14°	126.74° ± 4.35°
>1.80 m (n=13)	120.96°* ± 4.12°	131.28°** ± 3.78°

*statistic difference between columns *p< 0,05 ; **p< 0,01
O.S.(open handle); C.S.(closed handle)*

The elbow angle joint was not presented in table 1 because that in the beginning of the movement all individuals had the elbows in complete extension, not suffering angular alterations related to the size of span.

Table 2. Angulations of the shoulder and elbow along the different spans at the end of the movement

Spans	O.H.	C.H.	O.H.	C.H.
	Shoulder		Elbow	
<1,80m (n=13)	44,27° ± 9,67°	43,82° ± 6,28°	87,17° ± 6,63°	63,43° ± 5,57°
>1,80m (n=13)	41,01° ± 2,74°	43,81° ± 3,93°	79,93°* ± 8,11°	55,00°** ± 6,91°

*statistic difference between columns *p< 0,05 ; **p< 0,01
O.H.(open Handle); C.H.(closed Handle)*

In relation to the individuals' spans, regarding the different "handles", we can observed that there was significant discrepancy between two groups (higher than 1,80m and lower than 1.80m).Those ones with span higher than 1.80m have presented an angulation of the elbow joint smaller at the end of the movement in relation to the ones lower than that. Thus, the elbow reaches a larger flexion during the concentric phase of the exercise for those ones with spans higher than 1.80m. For the shoulder joint this angular variation has occurred in the beginning of the movement (table 1), however, at the end of the movement that discrepancy didn't occur (table 2).
Tests of 1RM developed with different "handle" types in the back pull exercise have shown higher performance results (p<0,001) by using the closed "handle" technique according to the table 3. On the other hand, regarding the RMs tests, the results have shown that the individuals accomplished a larger number of repetitions in the open "handle" (p<0,001).

Table 3. Values of 1RM and RMs from both "handle" techniques

	Closed handle	Open handle
1RM (n=11)	76 ± 11.89 kg	70.7 ± 11.44 kg *
RMs (n=10)	23 ± 2.16 RMs	26.7 ± 2.21 RMs *

** p < 0,05 (level of significance)
1RM: one maximum repetition
RMs: number of maximum repetitions at 60% of 1RM*

The maximum strength has presented higher values in an average of 7.5% in the closed "handle" in relation to the open one. It means about 5 kg heavier (or one plate of the equipment). On the other hand, the values of the located muscular resistance strength were larger in an average of 13.8% for the open "handle" technique.

DISCUSSION

Starting from the obtained results we can state that during the closed "handle" technique there has been an angular displacement in the joint of the higher elbow in relation to the other analyzed technique. This larger width of movement allows us to infer that has been occurred a larger work of the acting muscles in this joint during the movement (flexors of the elbow).
In a physical analysis we can state that with the largest movement arch traveled (angular distance), since the force (external resistance) is maintained, the largest will be the work developed once W = f x d. That verification exerts straight influence on the intensity of the exercise once that the movement width is one of the variables of training [24].
Physiologically, the largest width of the muscular movement in the exercise results in a larger crossed bridges recruitment of the antagonists muscles of movement as well as in a largest shortening of the sarcomeres allowing, thus, the development of this musculature in its whole width [13].
One factor that has influenced on this larger displacement during the closed "handle" is the verification that in the movement pattern for the open "handle" there is an instant when the elbow stops presenting constant angular alteration or, in other words, still there is movement in the shoulder joint but in the elbow joint occurs a stagnation of the displacement. From this moment on the muscles start

acting in an almost isometric way. That apparent isometry occurs in the last 15% of the cycle when the angulation stabilize near to the value of 85° (see figures 2 and 3).
In relation to the shoulder, the results have shown a statistically significant difference only for the beginning of the movement. That is due to the type of the adopted "handle", once in the closed "handle" the shoulder starts from a more abducted position than in the open one. Thus, the muscular action of the adductors muscles of the shoulder produce differentiated displacements in the segments with the variation of the "handle".
In relation to the spans, regarding the different handles in the bar, we have verified, that according to the tables 1 and 2, keeping the same bar and the same handle places for all the individuals it would happen different angular courses for the same analyzed joint.
In relation to the tests of maximum dynamic strength (1RM) and Maximum Repetitions (RMs), the results suggest that the use of the different techniques can exert influence on the appropriate prescription in REW when that has been based on these tests. The largest results obtained for the MDS, as it may be seen in the table 3, were always observed in the closed "handle" technique that was exactly the one that presented a largest course of the agonists muscles of each joint. The resistance strength (table 3) has presented an opposite behavior to the MDS, once the largest number of repetitions has been reached through the open "handle". Regarding the shoulder joint there is a pre-stretching of the adductor musculature which due to the length-strain curve of the skeletal muscle [21] it will be able to develop a better performance. On the other hand, for the elbow joint, that largest course of the flexor musculature as it was already seen doesn't necessarily implicate in a largest production of strength for contributing in the exercise, once for this muscular group the leverage factor overlaps the length-strain curve where the musculature generates a larger torque (articular useful strength) in the middle of the movement or, in other words, 90° [21]. Thus, the pre-stretching of the adductor musculature of the shoulder seems to be the best explanation for the superior performance of the closed "handle" technique in the test of maximum dynamic strength. A similar phenomena has been already shown for the horizontal adductors of the shoulder, prone-supinators of the forearm, and flexors and abductors/adductors of the hips [21]. On the other hand, in the located muscular resistance strength test, what seems best explain the performance on the open "handle" technique is the possible fatigue of the flexor muscles of the elbow by being a small musculature tends to resist for less time to the work, disabling, thus, a largest performance in the exercise.

CONCLUSION

The obtained results have allowed us to observe that the type of adopted "handle" exerts straight influence on the exercise. The results generate analyzes allowing us to state that the articular angles which suffer these variations (elbow and shoulder) are linked to the type of "handle", the size of the bar as well as to the spans of the individual . In this way, if the individual's span increases it generates, in the joint angles, the same result that if the size of the bar was reduced or if the "handle" was more closed. We have observed that the individuals with the largest spans present a larger flexion their elbows at the end of the concentric phase in relation to the ones with smaller span. Besides, they start from a more prolonged position of the shoulder adductors concluding, thus, that the flexors muscles of the elbow work harder and that the shoulder adductors muscles have a larger useful force.
It was verified that in the application of the closed "handle" technique there was more efficient for to work the flexor muscles of the elbow. Besides modifying the muscular action, still in this technique, there have been higher performance results in the 1RM test showing, thus, that is possible to achieve a larger performance through the closed "handle" when the maximum dynamic strength is the analyzed strength. However, when the located muscular resistance strength is analyzed, the best performance is reached through the open "handle" because the action of the elbow flexors muscles is smaller in this case, once that the precocious muscular fatigue of these muscles is a limiting factor on the performance of the shoulder adductors muscles in the exercise.

Considering and in according the literature, the application of different REW execution techniques or the change of implements and machines in order to modify the articular angles must be carefully analyzed and applied in the daily occupation.

CORRESPONDENCE
Josiele Vanessa Alves
Universtity of Santa Catarina State – UDESC
Physical Education, Fisioterapy and Sports -CEFID
Laboratory of Biomechanics
Street: Pascoal Simone, 358 – Coqueiros, ZIPCODE: 88080-350
Florianópolis – SC - Brazil
e-mail*: josialves_ef@yahoo.com.br*

REFERENCES

1. Badilllo JJG, Ayesterán, EG (2001). *Fundamentos do Treinamento de Força – Aplicação ao Método Resistido*. Porto Alegre: Artmed, 2nd ed.
2. Baechle T (1994). *Essentials of strength training and conditioning. National Strength and Conditioning Association*. Champaign: Human Kinetics.
3. Bompa TO, Cornacchia LJ (2000). *Treinamento de Força Consciente*. São Paulo: Phorte.
4. Campos MA (2002). *Biomecânica da musculação*. Rio de Janeiro: Sprint.
5. Dantas EHM (1995). *A prática da Preparação Física*. Rio de Janeiro: Shape.
6. Delavier F (2002). *Guia dos movimentos de musculação – abordagem anatômica*. São Paulo: Manole.
7. Escamilla RF, Fleisig GS, Zheng N, Lander JE, Barrentine SW, Andrews JR (2001). Effects of techniques variations on knee biomechanics during the squat and leg press. *Med Sci Sports Exerc* 33: 1552-66.
8. Fleck SJ, Kraemer WJ (1999). *Fundamentos do treinamento de força muscular*. Porto Alegre: Artmed.
9. Fragoso I, Vieira F (2005). *Cineantropometria*. Lisboa, Portugal: FMH edições.
10. Greene DP, Roberts SL (2002). *Cinesiologia: Estudo dos Movimentos nas Atividades Diárias*. Rio de Janeiro: Revinter.
11. Heyward VH (1998). Assessing strength and muscular endurance. In Vivian H Heyward. *Advanced fitness assessment and exercise prescription*. 3rd edition, Human Kinetics, p.105-120.
12. Hoffaman SJ, Harris JC (2002). *Cinesiologia: o Estudo da Atividade Física*. Porto Alegre: Artmed.
13. McArdle WD, Katch FI, Katch UL (1998). *Fisiologia do Exercício – Energia, Nutrição e Desempenho Humano*. Rio de Janeiro: Guanabara, 4 ed.
14. McGinnis PM (2002). *Biomecânica do Esporte e Exercício*. Porto Alegre: Artmed.
15. Moura JAR, Borher T, Prestes MT, Zinn JL (2004). The influence of different joints angles obtained in the starting position of the leg press exercise and at the end on the frontal pull exercise on the values of 1 RM. *Rev Bras Med Esporte* 10: (4) 269-74.
16. Moura JAR, Almeida HFR, Sampedro RMF (1997). Força dinâmica máxima: uma proposta metodológica para validação do teste de peso máximo em aparelhos de musculação. *Revista Kinesis* 18; 23-50.
17. Prestes MT, Moura JAR, Hopf ACO (2002). Estudo exploratório sobre prescrição, orientação e avaliação de exercícios físicos em musculação. *Revista Kinesis* 26; 22-33.
18. Signorile JF, Zink AJ, Szwed SP (2002). A comparative eletromyographical investigation of muscle utilization patterns using various hand positions during the lat pulldown. *J Strength Cond Res* 16: (4) 539-546.
19. Signorile JF, Duque M, Cole N, Zink A (2002). Selective recruitment of the triceps surae muscles with changes in knee angle. *J Strength Cond Res* 16: 433-9.
20. Simão R (2003). *Fisiologia e Prescrição de Exercícios para Grupos Especiais*. São Paulo: Phorte.
21. Smith LK, Weiss EL, Lehmkohl LD (1997). *Cinesiologia Clínica de Brunnstron*. São Paulo: Manole, 5 ed.
22. Tartaruga LAP, Black GL, Tartaruga MP, Coertjens M, Kruel LF (2001). Objetividade e Fidedignidade do Sistema de Digitalização Manual para o Movimento de Corrida. *Revista Perfil*, Porto Alegre.
23. Uchida MC, Charro MA, Bacurau RFP, Navarro F, Pontes Jr FL (2004). *Manual de musculação – uma abordagem teórico-prático do treinamento de força*. São Paulo: Ed. Phorte; 2nd ed.
24. Weineck J (2003). *Treinamento Ideal*. São Paulo: Manole, 9ª ed.